DISCOVERY

Monthly Notebook

- Double-edged Weapons
- Whither Biological Control
- The Transistor
- No Sense at All
- Operational Research
- Thundercloud Research

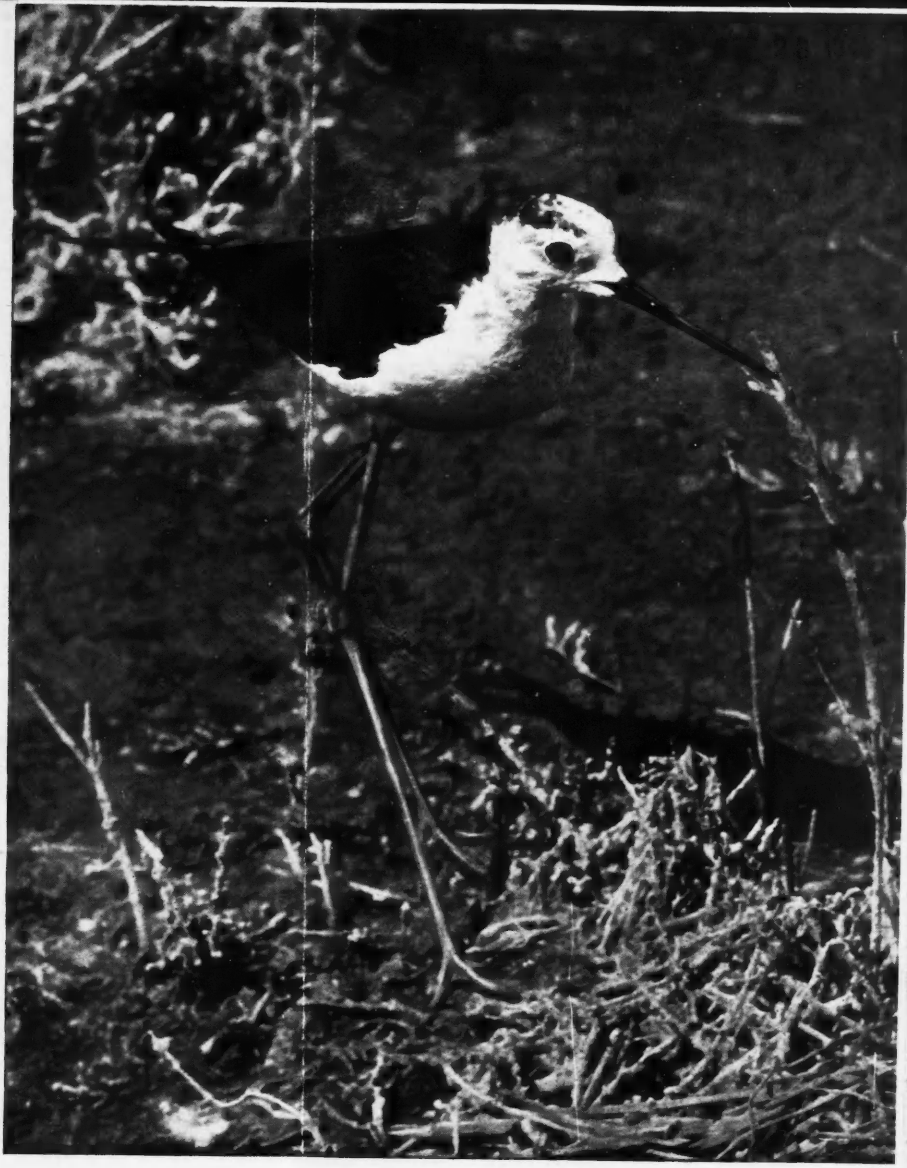
Atomic Energy Control: What Next?
Prof. H. C. Urey

Scientific Oil Prospecting
T. C. RICHARDS, D.I.C., Ph.D., F.Inst.P.

The Hangars Hide Uranium Piles
W. E. DICK, B.Sc., F.L.S.

John Newlands and the Periodic System
Prof. F. A. PANETH, F.R.S.

New Birds in Britain
R. S. R. FITTER



Black-winged Stilt

SEPTEMBER

1948

1/6

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

September, 1948 Vol. IX. No. 9

Editor WILLIAM E. DICK, B.Sc. F.L.S.

Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Published by Jarrold & Sons Ltd. Norwich. Tel. 21441

Advertisement Office: 161 Cheapside E.C.2. Tel. Met 9729

The Progress of Science

Double-edged Weapons

CONSIDERABLE alarm was expressed at the recent Commonwealth Entomological Conference over the situations which are arising through the extended use of the new insecticides, and especially of the 'systemic' insecticides of whose discovery a good deal has recently been heard. These are the substances which, injected into or otherwise applied to plants, render them toxic to insects feeding on their tissues (see DISCOVERY, June 1948, pp. 165–6, "Making Plants Kill their Own Pests"). It is obvious that if this could be widely developed, a vast new field of insect control could be opened up. But, say the entomologists, our knowledge of these new weapons is extremely limited and there is in this case real danger of running before we can walk. It is known that insects feeding on plants grown for a short time in solutions of these substances die: but that is all we do know. Why and how they die, and what kills them, are still pages in a closed book. Our ignorance of the effects of feeding livestock, for example, on plants so treated is complete.

It would seem that the use of tracers will be especially valuable in answering some of these questions and in the meantime, to quote speakers at the Conference, "it would be utterly wrong if these insecticides came on the market in the present state of our knowledge", for "our ignorance of these substances is simply appalling and there is very considerable danger in pushing ahead with these new compounds".

It is not only with these very latest lethal substances that care is needed. Dr. V. B. Wigglesworth, leader among insect physiologists, himself emphasised that there are many gaps in our knowledge of the working of even the best-known 'killers', such as DDT and Gammexane, and there is still in many countries doubt as to the extent to which these ought to be used where there is any chance of danger to stock or to Man. This may not apply, say, in tropical Africa where as someone has pointed out, "the dangers to life and health from wild animals, insect-borne diseases and even over-indulgence at the Club, are such as to cause most people to disregard the possible perils of the accumulation of DDT in the system".

Yet another effect which requires very close study is certainly that of these insecticides (especially Gammexane) on the balance of insects and microorganisms in the soil. To solve these and similar problems, the applied entomologist must cease to regard himself as an entomologist at all; he must be, in fact, a highly specialised plant pathologist. Nor is it only in the field of insecticides that *festina lente* should be the biologist's watchword. The much-heralded 'hormone' weed-killers, too, raise their own problems. An example, it seems, is that of the curious disease appearing last year (and in evidence again this season) on barley in East Anglia. Consisting in effect of various deformations of the ears, it long defied identification with any known condition; but it seems to be related to the treatment of the crops with these new weed-killer sprays.

Our latest weapons against insects and weeds are two-edged, and must be handled with corresponding care if mankind is not to be the loser through their use.

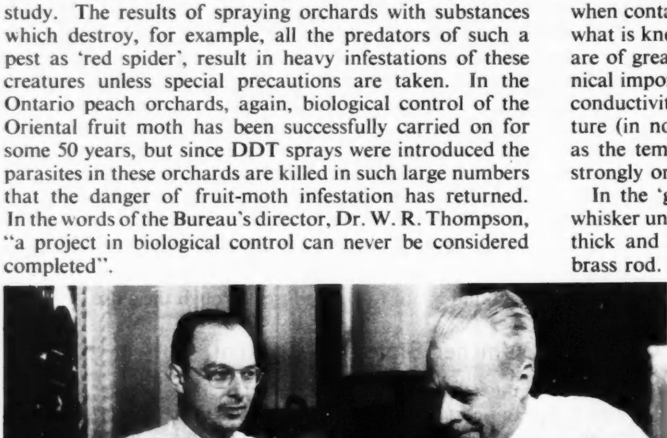
Whither Biological Control

SINCE the removal to Canada, in 1940, of the Farnham House Laboratory, for many years the centre of biological control for the Commonwealth, much less has been heard in Britain of this fascinating work. Many people are unaware that it is over a year ago since there was formed the Commonwealth Bureau of Biological Control, as a full-fledged member of the Commonwealth Agricultural Bureaux, with its headquarters at Belleville in Canada. Physically, the Bureau has expanded a good deal in recent years, for besides its home stations, it has laboratories in Trinidad, Bermuda, Montevideo and Zürich, and requests have been received for the establishment of out-stations in East Africa and India.

An important aspect of the Bureau's work (and one that is becoming apparent in other branches of entomology) is the need for more taxonomists. Between the wars, these specialists, together with the morphologists and other workers in the more static 'museum' branches of entomology, had been pushed farther and farther into the background. Now, after years almost 'on the shelf', they are

once more being appreciated and the need for trained workers in this field is becoming acute. Attention has been drawn to this through the time and money wasted in certain campaigns, on account of the incorrect identification of the insects concerned. At the end of the classic control work on the spruce sawfly (*Diprion polytomum*) carried out at enormous expense over a period of fifteen years, it was shown that the offending insect had been confused, through incorrect identification, with another and closely allied species whose distribution was different and which was attacked by different parasites. Where both species of a pest are attacked by the same parasites, it is of course not a matter of vital importance. But many of the best parasites are specific, and exact identification of a pest species in its original home may make all the difference between failure and success to control it by biological means. Where an insect is as rare and inaccessible in its native country as *Diprion* proved to be, correct taxonomy over a wide range of specimens is an absolute necessity. Other examples of faulty identification have occurred, in the case of the parasites, with the species of *Astrogaster* used against the pea-moth in Canada; and of *Pseudococcus*, the coffee mealy-bug, which is a pest in Kenya.

Other points to which attention is now being paid concern problems of population density, and the morphology and physiology of the parasites themselves. The effects of insecticides on parasites need very careful study. The results of spraying orchards with substances which destroy, for example, all the predators of such a pest as 'red spider', result in heavy infestations of these creatures unless special precautions are taken. In the Ontario peach orchards, again, biological control of the Oriental fruit moth has been successfully carried on for some 50 years, but since DDT sprays were introduced the parasites in these orchards are killed in such large numbers that the danger of fruit-moth infestation has returned. In the words of the Bureau's director, Dr. W. R. Thompson, "a project in biological control can never be considered completed".



The scientists who developed the transistor. (*Left to right*) Dr. John Bardeen, Dr. William Shockley, Dr. Walter H. Brattain.

The Transistor: A New Use for Germanium

ONE of the rarer elements for which important applications were developed during the last war was germanium, a hard but brittle silver-white metal. In powder form it is dull grey in colour. Its major physical and chemical properties were predicted by Mendeleef in 1871 when he published his periodic table, but it was not actually discovered until 1886, when the accuracy of Mendeleef's predictions was strikingly verified. Germanium is widely distributed in nature in very small amounts. In common with another rare element, gallium, its best commercial source is the flue dusts from certain gas works; the germanium content of the dusts varies with the kind of coal used, and may be as high as 1%.

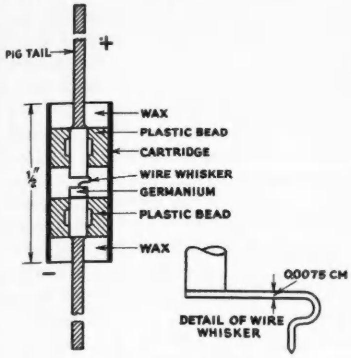
In 1939, partly owing to its high cost (about 30 shillings a gram or £700 per lb.), it had no commercial applications, although some of its alloys had interesting properties. During the war, however, in the development of compact light-weight radio equipment for use in proximity fuses and other devices, the possibility of using the 'crystal-cats-whisker' type of rectifier familiar to early radio enthusiasts in place of the bulky and fragile vacuum tube was revived, and a search was made for a crystal which would be more effective than the galena originally used. From many possible materials the final choice was germanium.

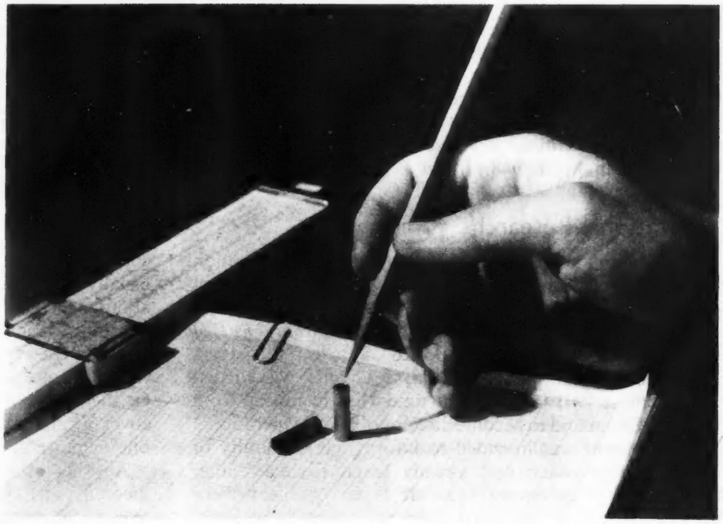
Pure germanium has a very high electrical resistance, but when contaminated with a small amount of tin it becomes what is known as a *semi-conductor*. Such materials, which are of great theoretical interest as well as increasing technical importance, are characterised by having an electrical conductivity which *increases* rapidly with rise in temperature (in normal metals the conductivity *decreases* slowly as the temperature rises), and this phenomenon depends strongly on the presence of impurities in the crystals.

In the 'germanium crystal diode', as the modern cats-whisker unit is called, a wafer of germanium about 0·5 mm. thick and 3 mm. square is soldered on to the end of a brass rod. The upper surface, which is highly polished, is touched by the sharp point of a fine tungsten wire whisker. Owing to the peculiar properties of the semi-conductor the conductivity at this fine point contact is directional, it being very much easier for electrons to flow from the semi-conductor to the metal than vice versa in this particular case.

The arrangement therefore acts as rectifier and can fulfil the function of the conventional diode valve without requiring the glass vacuum envelope or the current supply to heat the filament. There is no warming-up period before operation begins. The dimensions of the complete unit are about $\frac{1}{2} \times \frac{1}{4}$ in. compared with 3×1 in. for the conventional type.

A major advance in the history of electronics was the introduction of the third electrode or grid into the diode valve. The triode is capable of two new functions—oscillation and amplification—which are of very great importance. It was recently announced that, after much experiment, a germanium crystal diode had also been





(*Above*) Constructional details of a germanium crystal diode. (*Based on diagram in 'Electronics', February 1946.*)
(*Right*) The Transistor, as the germanium triode is called, can amplify as high as 100 to 1.

converted successfully into a triode. This achievement is the outcome of work on the theory of the solid state by Drs. W. Shockley, J. Bardeen and W. H. Brattain at the Bell Telephone Laboratories, New York. Few details are yet available, but it appears that the essential third electrode is another wire whisker touching the crystal within a few thousandths of an inch of the first. The application of a negative potential to one whisker controls the current flowing to the other in the same way that the potential of the grid controls the current flowing to the anode.

The new device has been called a 'transistor', and it is claimed that although at present limited in capacity, the transistor can perform any of the functions of the conventional triode and some new ones as well. There can be no doubt that its practical and commercial possibilities are very great.

No Sense at All

DISCOVERY does not trade in 'mysteries' and 'marvels' of science, and we try to keep both words out of our columns so far as is possible. But like a great many other people—indeed we might well say, like everyone else with the exception only of experts on cosmic rays and nuclear structure—we feel that 'mysterious' is the adjective to apply to the meson, and at the present time the addition of new facts to our stock of knowledge about mesons doesn't seem to make for any clearer understanding of their nature and behaviour. Those lay papers which thrive on mystery stories about science should find the meson very useful for several years to come, but these particles are proving a great headache to those papers who really want to inform their readers and not just amuse them. We particularly sympathise with the reporter of one such paper who wanted to know what a meson is, and phoned a scientific friend of ours, only to be told, "Look, chum, there's nobody in the whole world who knows what a meson is". We sympathise, too, with our scientist friend, who is always being rung up by newspapermen and who does a service to science by never turning away a sensible enquiry. That was the only answer he could give to that particular question, but he went on to say that mesons can be regarded as the glue that holds other particles together in the atomic nucleus, which may be termed a 'fully authorised analogy' in view of its use by such authorities as Dr. Janossy. (In his new book, which readers will find reviewed on p. 300 in this issue, Dr. Janossy talks about the meson, "which in a ghost-like state between existence and non-existence keeps atomic nuclei together and is the cement of ordinary matter".)

The meson is certainly a mystery at the moment, and the theme of its mystery has now been put to music. The Meson Song was first heard at a party which some American scientists held after a Seminar on mesons, and the words are reproduced from an article by George W. Gray in *Scientific American*.

We have mesons *pi* and mesons *mu*,
And mesons that serve as nuclear glue.
We have mesons large and mesons small,
Plus charge or minus, or no charge at all.

Chorus: What? No charge at all?
No! No charge at all.
A very small rest mass,
And no charge at all.

Vector or scalar or halfway between,
Sometimes the convergence can scarcely be seen.
Two hundred, four hundred, nine hundred mass,
All sorts of charges in every weight class.

Chorus

The forces exchange when at distances small;
There's the depth of the well and the height of the wall;
The quadripole moment a tensor demands
What very strange forces we have on our hands!

Chorus

Oh Bose! Oh Fermi! Perhaps Einstein, too,
Send a unified theory for both *pi* and *mu*;
With spin and statistics, adjustable range,
Nuclear structure is yours to arrange.

Chorus: What? No sense at all?
No! No sense at all.
A very small rest mass,
And no sense at all.

Postscript.—For those who prefer hard facts about mesons to jokes about them, here is a new one. The scientists of the Berkeley (California) team have now found that they can produce positive mesons as well as negative mesons with the 184-inch cyclotron. (The discovery of the artificial negative mesons was reported in DISCOVERY in April 1948.)

Operational Research

IN an attempt to rectify the lack of precise information on operational research, about which we have so often complained in these columns, Professor P. M. S. Blackett has published in the latest number of *Advancement of Science* (1948, Vol. 5, No. 17, pp. 26–38) two of the papers which he wrote during its early days. The first was written in December 1941 (at about the time when he moved from Coastal Command to become director of Naval Operational Research) and was intended to inform the Admiralty of developments which had already taken place in other operational research sections. It is an excellent piece of sales talk, and must have been very effective as such. It also contains some very forthright statements, well worth quoting, such as, "An Operational Research Section which contents itself with the routine production of statistical reports and narratives will be of very limited value. The atmosphere required is that of a first-class pure scientific research institution, and the calibre of the personnel should match this"; and again, "In general, one might conclude that relatively too much scientific effort has been expended hitherto in the production of new devices and too little in the proper use of what we have got".

In the history of the development of operational research methods, the second document is, however, of much greater interest. It is an introduction to the methodology of the subject, written for new recruits to the field of operational research. The published form dates from May 1943, though the document existed in earlier editions from 1941 onwards. The problem that the operational research worker has to solve is this; given the available statistics on the subject, how can a weapon, or a tactic, or a strategy, be altered in such a way as to give an improved result. One method of solving the problem is to select certain of the variables as specially important and so to work out the solution in a purely theoretical way. A classic example, dating from the first world war, is Lanchester's theorem, which states that (under certain greatly simplifying assumptions) the strength of a force is proportional to its fire power per unit multiplied by the *square* of the number of units. Thus increases in fire power give better proportional results than increases in size.

Such theoretical methods are in practice of very limited value, because the situation is usually too complicated for theoretical solution, and because the method does not allow one to approach a solution by gradual approximation, taking account step by step of more and more complicating factors. In practice a variational method is usually far more useful. Given an operational situation about which information is required, the scientist looks for another situation which is as near to it as possible. He then tries to estimate in what way the variations between the one situation and the other will affect the result. Or, beginning from the present situation, he tries to discover what improvements could be produced by altering one or more of its elements.*

Another principle, which Blackett calls an 'equilibrium theorem', enables one to pick out from the tactical derivatives those which are most likely to give significant improvements. Obviously if an operation is repeated many times, the participants by trial and error will discover tactics which bring the yield near its maximum. Now near the maximum the derivatives are small—that is, a change in the variable will only produce a small change in the yield. However, there will be exceptions to the general statement that the participants will bring each variable to the value giving maximum yield. For example, their orders may be too rigid, so that they do not have a chance to try the effect of changing certain variables. Or again, the conditions may be such that the participants never have the opportunity to observe the effects of changing certain variables, or the effect may not have been statistically analysed—in which case they are not likely to choose the best values for them. It is therefore to these latter types of derivatives that the operational research worker will give greatest attention. Some particularly striking examples of the improvements that can be achieved by statistically analysing the effects of variables previously left to intuitive considerations occurred in the case of N. Atlantic convoys. For instance, the effect of the size of the convoy on safety had not received scientific attention, and the balance of intuitive opinion was that large convoys were more dangerous than small. But on analysis, it was found that

* This method can be stated mathematically as follows:

Let Y denote the *yield* of the known operation—which might be men killed or U-boats sunk, or planes immobilised by bombing aerodromes. There are to be considered various variables X_1, X_2, . . ., representing such factors as size of forces employed, speed of aircraft, and so on. Then if the yield of the new operation is Y', we have

$$Y' = Y + \frac{dY}{dX_1}\,\delta X_1 + \frac{dY}{dX_2}\,\delta X_2 + \ldots.$$

Here $\frac{dY}{dX}$ is the *derivative* of Y with respect to X_1 (roughly speaking, if a small change in X_1 produces a small change in Y, $\frac{dY}{dX_1}$ is the ratio of the latter to the former). And δX_1 represents the change in the variable X_1 between the known operation and the operation about which information is required. Thus the formula states that to find the new yield Y', we take the old yield Y and add to it the derivative of Y with respect to each variable multiplied by the change in the variable between the two operations.

Now the differences δX are known, and the derivatives $\frac{dY}{dX}$ can usually be found to a fair degree of approximation. Sometimes they can be deduced from the statistics of earlier operations. And if it is necessary to resort to theory, the theoretical considerations involved are much simpler than for the wholly theoretical method mentioned earlier. In practice, the research worker will consider one derivative at a time; that is, he will investigate the results of changing variables one at a time. Naturally he will want to begin with those that are likely to give biggest result for smallest change, and here he can be guided by the general principle that he should take into account "first the *tactical derivatives* to judge what changes of *tactics* would lead to improved yields; then the *material derivatives* to estimate the effects of improved *weapons*. Many mistakes have been made by inverting this order, e.g., a new weapon may be demanded which promises an improved yield over existing weapons with existing tactics, but which may prove to give a lower yield compared with existing weapons with improved tactics."

increasing the average size of a convoy from 32 to 54 reduced the proportional losses from 2·5% to 1·1% (other things, including the number of escort vessels, being equal). That is to say, this simple *re-arrangement* of the units involved, without any addition to the forces employed, reduced losses to less than half; whereas a 50% increase in the number of escorts reduced the losses by only a quarter.

Usually the pages of an operational researcher's reports, or the many more pages by which he arrived at his results, will not be sprinkled liberally with symbols like $\frac{dY}{dX_1}$, δX_1 and so on. He will be bearing in mind all the time the principles which have been stated in mathematical form. But he will be making adjustments to them from time to time, so that his report will eventually appear something like the following example, which again is taken from practice:

Professor E. J. Williams, whose researches revolutionised the tactical use of aircraft versus U-boats. His premature death in 1946 was a severe loss to theoretical physics.

During the anti-submarine campaign in the N. Atlantic in 1941 an analysis was made of the conditions in which the U-boats were at the moment of attack by aircraft. They were, of course, all on the surface when spotted, and it was found that 34% of them were still visible when the plane put in its attack. The rest had succeeded in diving before being attacked: 27% had been submerged not more than 15 seconds; 15% between 15 and 30 seconds; 12% between 30 and 60 seconds; and 11% more than 60 seconds. It was further found that these figures remained nearly unchanged throughout 1942 and were nearly the same on the eastern seaboard of the U.S.A. as on the Atlantic.

Coming now to our specific example of how an operational researcher works, it was desired to know how a change in the colour of the attacking aircraft would affect the number of U-boats attacked while still visible. The calculations, as carried out by the late Professor E. J. Williams, runs as follows:

By observation it was estimated that painting a Whitley white instead of black would enable it to get 20% nearer the U-boat without being sighted. Furthermore, it was known that it takes a U-boat about 45 seconds to dive. So a U-boat which has been submerged for t seconds when attacked by a black Whitley must have seen the plane $(t + 45)$ seconds earlier. If v is the speed of the plane, its distance from the U-boat at the moment of sighting must have been $(t + 45)v$. Thus if the plane had been white, it would have got to distance $\frac{4}{5}(t + 45)v$ before being sighted and the U-boat would only have had $\frac{4}{5}(t + 45)$ seconds in which to dive. The U-boat would be caught just at the end of its dive, if this last time were equal to 45 seconds, i.e., if $t = 12$ seconds. Thus a White Whitley would catch on the surface all those U-boats which a black Whitley would catch either on the surface or submerged for not more than 12 seconds. Then from the statistics given above about the condition of U-boats at the time of attack, we can deduce that there will be an increase of the order of 30% in the number of U-boats attacked while still visible. As an attack on a visible submarine is far and away more effective than on one which has submerged (and presumably taken evasive action under water), this is a very remarkable gain, to be achieved at the cost of few tins of paint.

Many readers will be interested to know that within a few months a good deal more information on operational research will have been published. Professor C. H. Waddington, who was with the Operational Research Section of Coastal Command, has one book in the press, and we hear that an account of the methods of applications of operational research in peace and war is being prepared for H. M. Stationery Office.

Thundercloud Research

BOTH in Great Britain and the United States, war-time requirements have led to many new observations on thunderclouds—in Britain new knowledge was obtained by studying the cables of barrage balloons, and in the United States through an investigation of the radio interference experienced by aircraft when flying through cloud. The barrage balloon observations were briefly mentioned in the March 1948 issue of DISCOVERY. In thundery weather, transient currents of several hundred milliamps were often observed. The Americans, investigating radio interference, made observations not merely below thunderclouds but *within* them. The Precipitation Static Project, as this research team was called, had its headquarters at Minneapolis and had at its disposal three aircraft, seventeen physicists and engineers, a supporting laboratory organisation, and a hangar with sufficient clearance to enable high-voltage experiments to be carried out on full-size aircraft suspended within it. Special recording instruments were also designed for the 'project' by the U.S. Naval Laboratory. These included an electric field meter, suited for installation on the 'belly' and upper surface of the aircraft, and an 'artificial charger', by means of which the electric charge normally acquired when flying through cloud could be neutralised. The expectation was that radio interference was due to the charging-up of the aircraft, and this was confirmed. Voltages of more than half a million were often reached, and the immediate source of interference was the development of the corona type of discharge. Charging-up, it was found, could be due to two different types of process. The greatest rate of charging was experienced in flight through extended clouds of dry ice or snow, and was due to the static electricity developed through the friction between the ice or snow and the skin of the aircraft. The second source of charge—which gave the project its name—was the impact on the aircraft of electrically charged droplets of water, and it was the need for precise information about this effect which led to the detailed studies which were made of

cloud conditions. (Incidentally, the 'artificial charger' already mentioned made use of the same effect, operating in reverse. Charge was given to the aircraft, or to particular sections of them, by discharging from a stream of water droplets, which were highly charged, both the amount and the sign of the charge being controllable.)

The thundercloud observations were made during flights through ten different clouds, and on one occasion the investigating aircraft was itself struck by lightning. The electric field just before the 'strike' was recorded as 3400 volts per centimetre. This was in the course of a level flight through the cloud at a height of 12,900 feet, and a field of 2000 volts per centimetre in the reverse direction was twice recorded. For the other nine thunderclouds through which flights were made, the highest field encountered averaged 1300 volts per centimetre. On one occasion successive traverses were made through the same cloud at 5000, 10,000, 12,500 and 15,000 feet; the results showed that reversals of field were frequent, and the greatest fields in either direction were at the two highest levels. There was also abundant evidence to suggest that measurements of field made in a vertical direction only may underestimate considerably the strength of the total electric field. For example, the 'strike' already mentioned entered the right wing of the aircraft and left by the nose—that is, its course was in a predominantly horizontal direction—and the same impression was confirmed by other measurements in which the 'artificial chargers' were used to balance the external field due to the thundercloud.

It is of interest to compare these measurements with those obtained before the war at Kew Observatory with sounding balloons. These suggested, as summarised by Sir George Simpson, formerly director of the Meteorological Office, that the normal field within a thundercloud was of the order of 100 volts per centimetre, "except in relatively small regions in which lightning discharges originate". This figure is no more than about one-hundredth of that at which a flash or lightning type of discharge would normally develop. By contrast these American measurements suggest that electrical fields approaching the flash discharge level are common, and not the exception, within thunderclouds. Other measurements were made in clouds of other types than those of thunderstorms. Where there was little vertical movement of air within the cloud, the electric field was found to be less in all cases than 40 volts per centimetre, even when rain was falling. In the absence of rain, the observed field was always less than 10 volts per centimetre. The difference between thunder and non-thunder conditions was therefore clear-cut and marked, as was also shown in the barrage balloon measurements made in England. Compared with the cable currents of several hundred milliamps which, as already mentioned, were recorded in thundery conditions, currents in cloudy conditions but without thunder were of the order of several milliamps, or about a hundred times less.

REFERENCES

R. Gunn. *Journal of Applied Physics*, 1948, Vol. 19, p. 481.

Simpson and Robinson, *Proceedings of the Royal Society*, A, 1941, Vol. 177, p. 281.

Submarine Explosions

ON one occasion in the last war a 250-lb. bomb fell on the bridge of one of our submarines which had just begun to dive. The bomb was set to go off at a certain depth, which it duly did. Yet the submarine was only damaged superficially, the periscope and parts of the conning tower being blown off. This is a very striking example of a fact well known to those who go down under the sea in ships, namely that an explosion above the submarine is much less damaging than a similar one at a similar distance below it.

The explanation of this phenomenon is one of the more interesting products of research in the last war described in *Science at War*, the semi-popular history of the scientific war effort by J. G. Crowther and Prof. Whiddington. It appears that an underwater explosion is a much more complex affair than one in the air. At first the explosion products form a very hot gas bubble which rapidly expands. Since the gases and the water acquire a very high momentum, the bubble expands well beyond its equilibrium size. Thus, when it reaches its maximum, it starts to contract. And again the momentum carries the contraction well beyond the equilibrium position, so that on reaching its minimum the bubble expands again. It may perform three or more of these oscillations before it breaks up.

Now each expansion is equivalent in effect to another explosion. It produces its own shock wave which is capable of doing damage—though naturally the intensity diminishes each time. Meanwhile the bubble, being lighter than water, is rising. And it is now easy to see why an explosion below a submarine is so much more dangerous than one above—in the former case, the later oscillations may take place nearer the vessel, or even in contact with it. The effect is further complicated by the fact that, according to a general hydrodynamic law, a bubble of this type is sucked towards any rigid surface such as the hull of a submarine or ship.

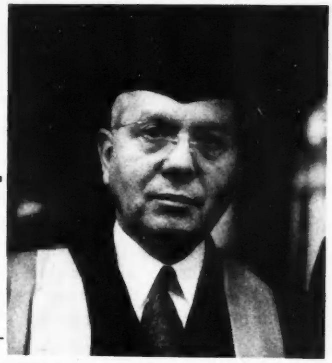
This phenomenon has to be taken into account when using seismic equipment for detecting oil deposits that lie under the sea (see p. 280).

This study of the 'bubble effect' is an example of the work done by the 'Undex Works' established by the Admiralty in 1943 at Rosyth, and now known as the Naval Construction Research Establishment. High-speed photography has been extensively applied there to elucidate the nature of underwater explosions and—what is much more difficult—their effects on ships and other structures. Much use was made of the Arditron, the gas discharge tube developed to provide a flash of high intensity for super-high-speed photography. Our note about the Arditron published in November 1946 included a photograph of the apparatus devised at the Naval Construction Research Establishment for taking successions of photographs at a fixed frequency of 1000 flashes per second. It was this apparatus that made detailed study of the 'bubble effect' possible.

ATOMIC ENERGY CONTROL IS IMPOSSIBLE WITHOUT WORLD GOVERNMENT

by

Professor H. C. UREY



In my opinion the experience of the past three years demonstrates that there is no easy road to the solution of a large problem. It is necessary to go back to fundamentals, and succeed or fail by facing the fundamentals of the problem no matter how stubborn or how difficult that may appear to be.

The proposals for an Atomic Development Authority would not have worked had they been adopted as they were proposed by Mr. Baruch before the United Nations. It was always my hope while I was one of Mr. Baruch's advisers that someone would see the limited character of these proposals and make the initial suggestion that they must be greatly extended in scope if they were to grow into a workable scheme at all. No one did so, and it was obvious two months after the beginning of deliberations on June 14, 1946, that there would be no success along these lines.

It is impossible to control anything through the medium of any organisation unless that organisation has the sovereign right to control. Because nothing remains static in human affairs, the organisation must have an adequate mechanism of a dynamic character to take care of the control of any problem. These two conditions add up inevitably to the establishment of a world government if atomic energy is to be controlled. It must possess the sovereign right to control, from which there would be no appeal to higher authority. Experience has shown that governments must have a mechanism for the enactment of law, methods for its enforcement, and courts to adjudicate disputes. They must have a means of supporting themselves by taxation. The Atomic Development Authority as proposed by Mr. Baruch would have had a rather hazily defined and limited sovereignty inadequate to the problem at hand, but would have had no adequate mechanism for the other powers described. No adequate international control of atomic energy was possible under such circumstances.

People say that it is impossible to secure world government at the present time, which I think is probably correct, but I wish to say that neither can we get control of atomic energy without it, and both of these statements add up to a very unhappy conclusion.

Humanity has faced unhappy conclusions before, but perhaps not one quite so dismal as this, and we may ask what we should do, if anything, in the immediate future. If we do nothing but drift, a global war is in prospect, with, I believe, Europe seriously damaged or destroyed. If we make any aggressive moves along the line that Mr. Friedwald suggests, we are likely to have a global war, with—again—Europe seriously damaged or destroyed. It therefore appears to me that no matter what we do there is a strong probability of very bad results.

Under these circumstances, I think it will be necessary courageously, even desperately, to do what we think is the correct and progressive thing in the situation, and hope that Providence smiles upon us. I believe that we should strive for a world government in all countries of the world by any effective means that any of us can see. I believe that at the present time Russia will not join in such plans, but I might be wrong about this. Regardless of whether she will or not, the western countries should proceed nevertheless. Some people will say that this is an alliance against Russia. It will be such an alliance for some, and perhaps it is even necessary that there be such an alliance. But the important thing is to remember that it is necessary to begin organising the many separate sovereignties of the world into one, and without that solution no progress is made anyhow. All of us, however, should keep in mind the fact that our problem—namely, the avoidance of the use of atomic bombs, or more generally the avoidance of a modern war by any methods whatever—cannot be accomplished in the end without including all countries of the world in a world government. If all of us can keep that objective firmly in mind, and recognise that no war promotes the good will and understanding that is necessary to a successful government, perhaps it may lead us to try to avoid wars of all kinds while we move toward this great objective.

"NATURE" ON THE DEADLOCK

When the Atomic Energy Commission reports this failure to the General Assembly of the United Nations, the members of the Assembly will have to decide whether or not to attempt to work out a collective scheme independent of the U.S.S.R. That will clearly have to be done outside the United Nations Organisation. The breakdown of these protracted discussions should make clear the need for realism . . . and stress the plain fact that the so-called control urged by the U.S.S.R. is likely to be even more dangerous than no control at all. At the least the breakdown should stimulate clear thinking on the whole question of defence, including civil defence, which is indispensable to any effective system of national or of collective defence.

Correspondence arising from this series of articles will be printed in our next issue.

Scientific Oil Prospecting

AN ACCOUNT OF GEOPHYSICAL METHODS USED IN THE BAHAMAS SURVEY

T. C. RICHARDS, D.I.C., Ph.D., F.Inst.P.

In the early days of oil prospecting nearly a century ago, the mode of occurrence of oil in the rocks underground was imperfectly understood, and many of the holes drilled showed no traces of oil. As time went on the nature and shape of geological formations, at depth, were found to have an important bearing on the existence of oil, and no drilling was done in unproved areas until the geologist had studied the various rock formations outcropping at the earth's surface and deduced their behaviour underground. This is no easy task, for a variety of factors may enter to make the postulated shape or structure very approximate, and it has been common practice in the last twenty-five years to improve the geological picture by applying geophysical methods before embarking on an expensive drilling programme.

These methods make use of the variation in the physical properties of different types of rock. One method depends on the increased gravitational pull on approaching a buried rock formation, which is denser than the surrounding material. This change in gravity is detected by sensitive gravimeters, which can measure less than one part in 10 million of the earth's gravitational pull or less than one-tenth of a milligal.* One common type of meter consists essentially of a sprung mass, and the very small increase in length of the spring due to an increase in gravity is magnified by a lever and optical system. In order to reduce any unwanted thermal changes on the spring to a minimum, the gravimeter is housed in a constant-temperature container. In oil field exploration, a change of less than one milligal may be due to a buried anticlinal (dome-shaped) limestone formation which may act as an oil reservoir.

A second method depends on the variation in the magnetic attraction caused by different degrees of magnetisation of the underground rocks. As a general rule, the more highly magnetised rocks occur within the basement, as we call the old igneous crust of the earth, which in many parts of the world is now covered with thousands of feet of sediments, such as limestone, shale and sandstone. The basement may consist largely of granite which is more magnetic than the sediments; often there are very highly magnetic rocks in the basement which have intruded into it from the deeper parts of the crust. Large changes in the magnetic force over the earth's surface are therefore usually due to these intrusions, and it is possible to determine their approximate depth (which is equal, of course, to the thickness of the sediments above them) by a study of the magnetic anomaly they cause. If it appears that there is only a thin cover of sediments, the oil possibilities of the area are usually slender. Land magnetometers are, in principle, sensitive dip-needles; the needle, however, is balanced by a weight, so that the needle lies horizontally, and the measure of its deflection is proportional to changes in the vertical magnetic force. A bi-metallic device serves to keep temperature effects to a minimum. A good magnetometer is sensitive to a change of one part in 25,000 of the vertical magnetic force in England—or two gammas—so that deep intrusions with an effect of one hundred gammas* or more are easily detected. Anomalies of only a few gammas may be due to uplifts in the general basement and are, therefore, not so easily detected.

A third method, usually more expensive than the first two but more informative, makes use of the fact that a wave, generated by firing a charge of dynamite in the upper layer of the earth, on passing downwards is reflected back whenever the nature of the rocks change. The times of travel of these echoes, which are picked up by sensitive geophones, can easily be translated to depth measurements from known travel speeds. These formational speeds are conveniently measured by taking observations at various depths in a deep well, the charge being fired close to the well head. An alternative to this seismic *reflection* method is the *refraction* method which, however, has better application when the formation is very thick, and its characteristic speed greater than that of the rocks above it. In this case, at distances large compared with the depth, the first pulse of energy to arrive is that which has been refracted into the high speed formation, through which it travels with its characteristic speed and refracted out and upwards to the geophone. The angle of refraction is a function of the low and high speeds, and this together with distance and time measurements from a series of geophones in line enable depths to be computed. A modification of this method is given when the distance between geophone and firing point is kept constant, the geophones lying on an arc of a circle. If the high speed pulse arrives first at all geophones, any time differences are due to changes in depth in the neighbourhood of the arc.

On land, geophysical instruments and techniques are largely standardised from long experience, but when the gravimeter, magnetometer or geophone is required to operate in marine areas, novel procedures are called for. During the last two years, several major oil companies have been carrying out marine surveys in the Bahama Islands. These islands, which together cover an area of 4500 square miles, are the exposed parts of an otherwise submerged flat-topped mountain system, intersected by narrow ocean deeps varying from 800 to 2000 fathoms. In an area of over 40,000 square miles the submergence is no more than 5 fathoms, and it was in this vast marine area that exploration was mainly directed.

Measurements with a gravimeter at sea have been achieved in three different ways. In the first, a rigid and stable tripod is lowered to the sea bed from the stern of a suitable craft, and the observer places his instrument on a small platform at the top of the tripod. Fig. 3 shows a 25-ft. tripod weighing nearly two tons; this tripod is strong

* The unit of acceleration due to gravity is one centimetre per second per second, and is called a *gal*; in practice this unit is too large, so a *milligal* (one thousandth of a gal) is the accepted unit.

* The unit of magnetic force is the *gauss*; a *gamma* is one hundred thousandth of a gauss.

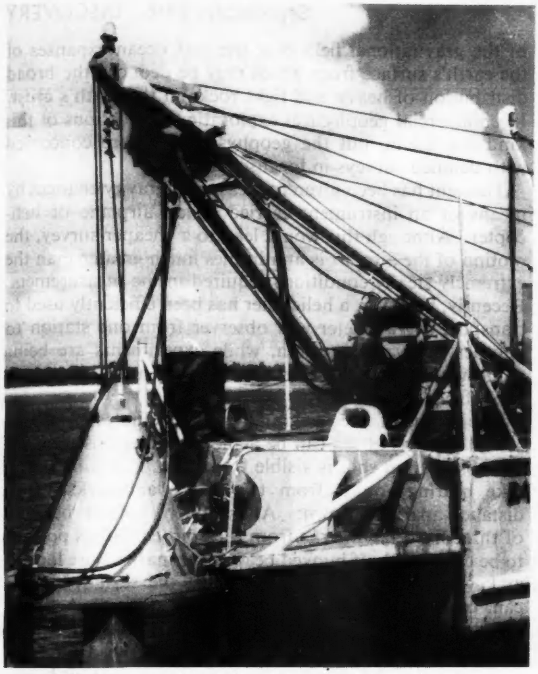


FIG. 1.—In one kind of gravity survey the gravimeter and observer are housed in a diving chamber which is lowered to the sea bottom. Here is the chamber secured in a cradle at the stern of exploring vessel.

FIG. 2.—The gravimeter is being handed to the observer inside the chamber.

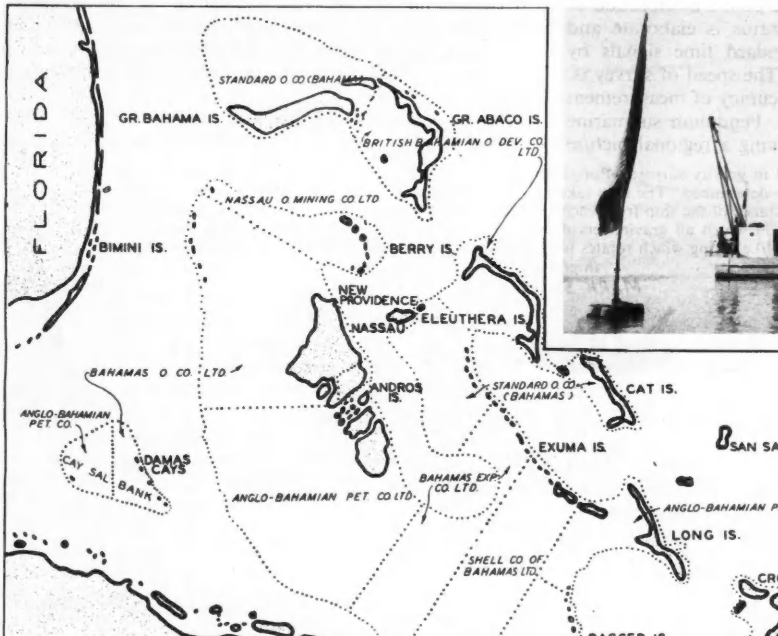


FIG. 3 (*above*)—Measuring gravity from a 25-foot tripod. Note the frame for hoisting tripod to stern of ship. On left is a marker beacon.

FIG. 4.—Exploration concessions in the Bahamas (*from Petroleo Interamericano*)

enough and stable enough to support the observer, but observations are generally not possible in wave action incident to winds of over 20 miles per hour. In the second, the gravimeter and observer are housed in a diving chamber which is lowered to the sea bottom. Here the motion of the water, even when the sea is rough at the surface, is comparatively quiet (unless strong currents are flowing) and observations can be made quickly. A two-ton diving chamber, whose conical shape (Fig. 1) gives maximum stability, is served with an air line and telephone from the parent ship, while a diver is always in attendance in case of accidents which are extremely rare. The operation of lowering and raising the chamber in a rough sea is somewhat hazardous, and again we find that the wave effect from a wind of about 20 miles per hour is a limiting factor. In the third method a gravimeter in a special housing and operated by remote control is lowered to the sea bed. The housing is supported by three legs, each of which may be raised or lowered by internal servo or electro-magnetic devices controlled from the ship. The position of exact level and the actual gravity measurement are given on electrical recording meters, the second being calibrated to read milligals.

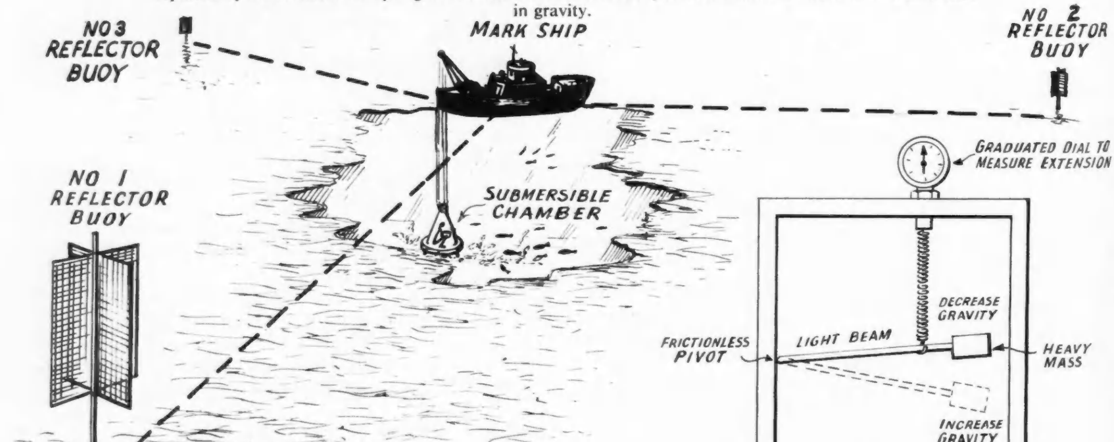
The gravity methods described above all refer to comparatively shallow water, although measurements have been taken with the diving chamber at a depth of 100 feet, and the remote control gravimeter at 200 feet. In the ocean deeps, however, measurements are made with a gravimeter installed on gimbals in a submarine which submerges to a constant depth for each reading. The meter is of the pendulum type in which differences of gravity are determined from the changes in the period of vibration of a pendulum. The complete apparatus is elaborate and provision is made to receive standard time signals by wireless for calibration purposes. The speed of survey is, of course, much slower and the accuracy of measurement lower than in the other methods. Pendulum submarine surveys are of especial value in giving a regional picture of the gravitational field over the vast ocean expanses of the earth's surface from which may be deduced the broad distribution of heavy and light rocks in the earth's crust. In commercial geophysical exploration, deductions of this kind are useful, but the geophysicist is more concerned with detailed surveys in localised areas.

Thought has been given to measuring gravity changes by means of an instrument carried by an airplane or helicopter. Although this would lead to a cheaper survey, the motion of the aircraft is at all times much greater than the extremely steady conditions required in the measurement. Recently, however, a helicopter has been efficiently used to transport a gravimeter and observer from one station to another in swampy terrain, while experiments are being made with a remote-controlled instrument lowered on a cable from a helicopter.

The fixing of the geographical co-ordinates of all observed stations at sea can be achieved in various ways. If the observation ship is visible from land, it is sufficient to take bearings on it from two fixed landmarks whose distance apart is known. Alternatively sextant bearings of three fixed landmarks from the ship enable its position to be calculated. If buoyed beacons or markers are located at key positions already established, the sextant method can, of course, be extended to great distances. A better, speedier and more accurate method is that known as 'taut-wire'. Here a fast-moving ship pays out a thin steel wire from a winch between three anchored marker buoys, a few miles apart from each other. Small buoys with sinkers attached are dropped overboard at every mile, or wherever a gravity observation is required, and the length of wire paid out between the marker or corner buoys noted. Starting with two fixed marker buoys, all other positions are triangulated in this way; the accuracy of fix may be improved by running cross ties in the triangulation network.

Radar surveying has also been used with success in the Bahamas. The apparatus is similar to that now used on

FIG. 5.—Radar is used in gravity surveys. Buoys bearing corner reflectors are moored at points whose positions are accurately determined. The time taken for radar echoes from the corner reflectors to return to the ship gives the distance of the ship from each buoy, and hence its position can be calculated. FIG. 6 (*inset*).—The principle on which all gravimeters depend. In some instruments the longitudinal spring is replaced by a flat clock-like spring which rotates when extended; this rotation is a measure of a difference in gravity.



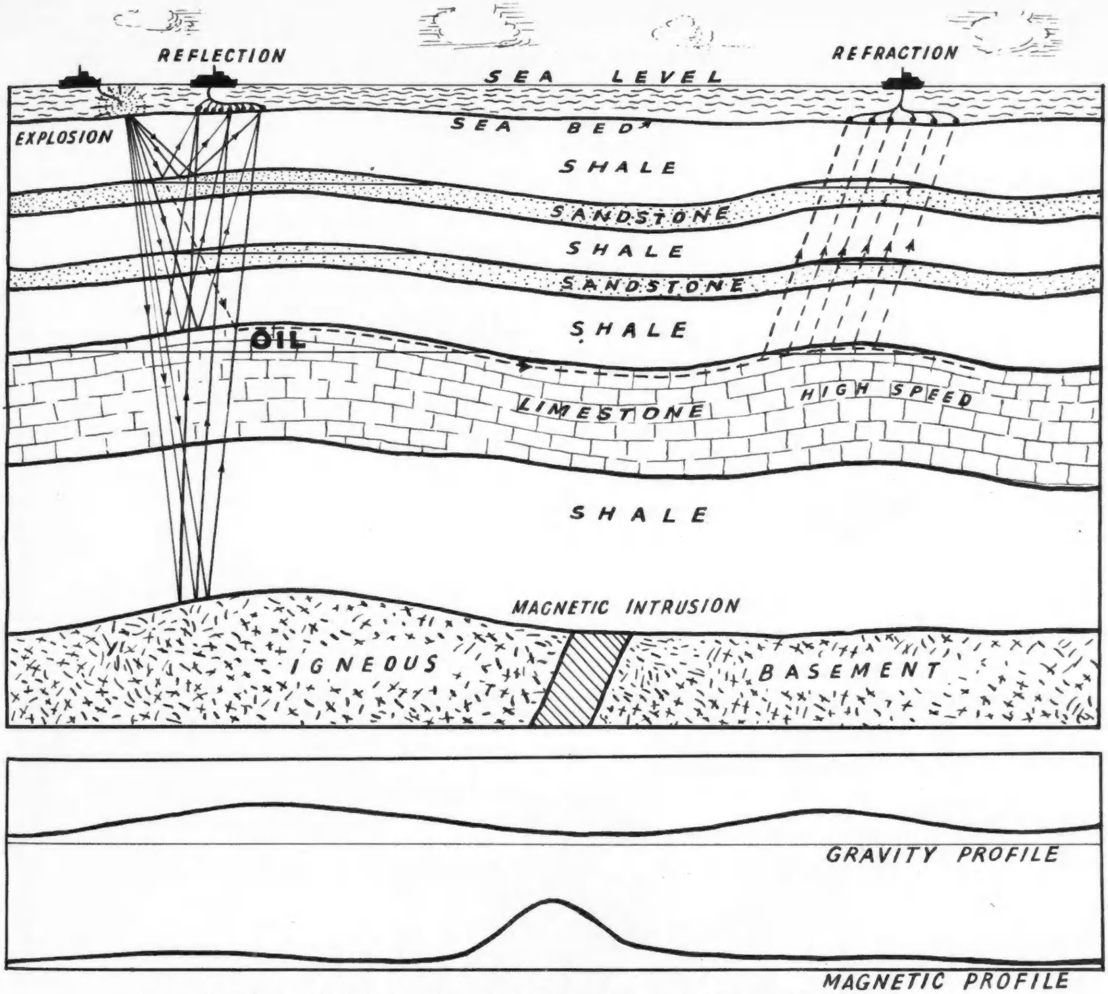


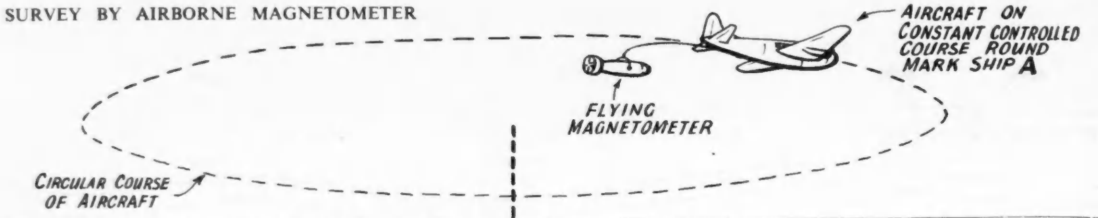
FIG. 7.—This diagram illustrates the seismic reflection and refraction methods, and the results to be expected from gravity and magnetic surveys.

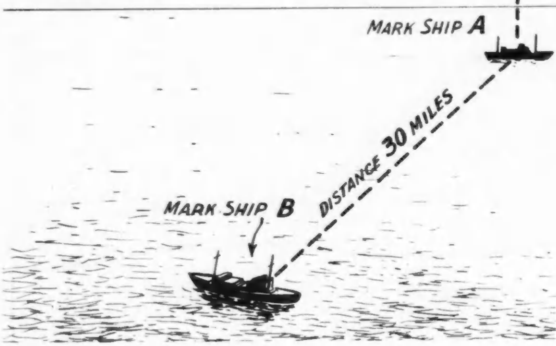
many ships as an aid in navigation. A short-wave wireless beam, a few centimetres in length, is sent out from a directional antenna at the top of a ship's mast, and any obstruction in the path of the beam, such as another ship or land, acts as a reflector, and can be seen as a light spot on the screen of an oscilloscope in the receiving apparatus. The screen is calibrated to read distance. In marine triangulation by this method, the observation ship fixes its position by taking distance readings from at least two special reflecting targets whose positions have already been determined. The targets conveniently take the form of two wire-mesh screens at right-angles to one another and mounted on an anchored float to a height of at least 10 feet. Good signal strength, which is independent of visibility conditions, up to distances of nearly 10 miles may be obtained from steady targets.

All gravimeter measurements must, of course, be referred to a datum which is usually mean sea level, before comparisons can be made. At sea, therefore, the height of the gravimeter relative to the level of the sea at the time of observation is recorded and corrected to mean sea level.

When the gravimeter is above mean sea level, as it is in the case of the tripod method of observation, the earth's gravitational force is less, by a small amount, than at mean sea level, and a simple correction is applied; another correction is due to the fact that at the time of observation, the gravimeter may be effected by the pull of the layer of water between it and mean sea level. The combined correction is called the Bouguer effect which in special cases receives a further correction if the topography of the sea bed is especially large near the observation station. A final correction is due to the fact that the earth's gravitational force increases from the equator to either north or south poles.

When the positions of the stations and corrected gravity values are computed, contours are drawn through points of equal value and thus give a gravity relief map, the 'highs' indicating uplifts in the underground, or the under sea-bed formations, which are so important to the oil geologist.





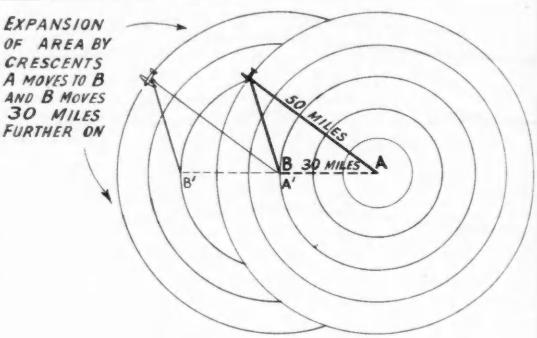
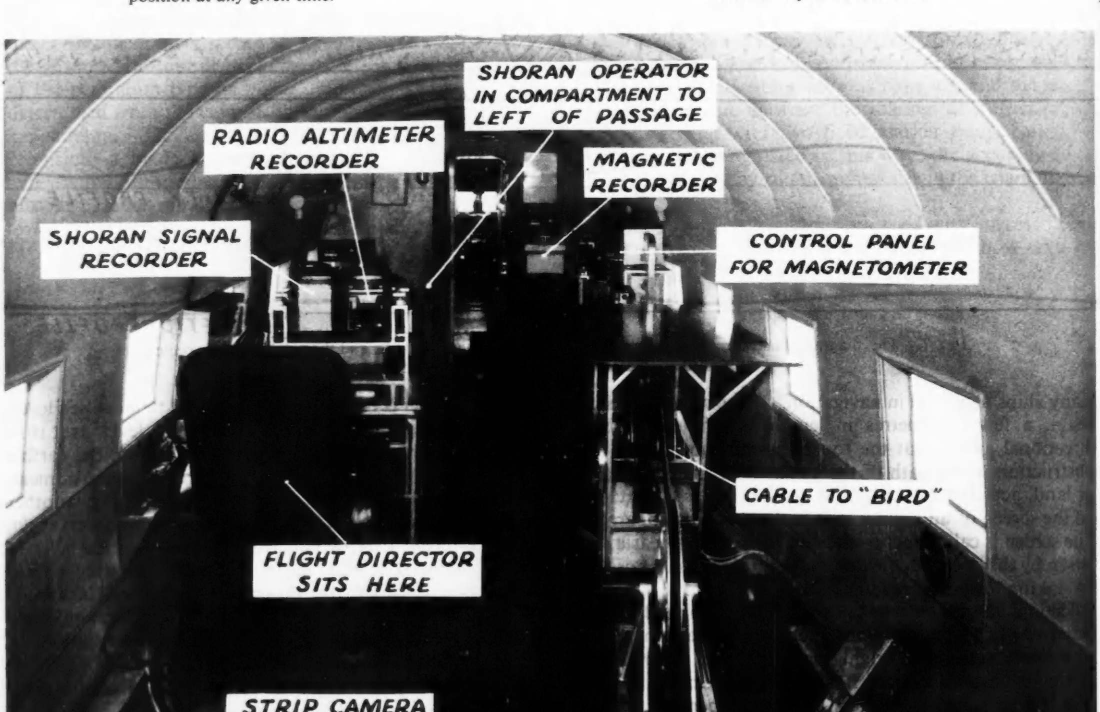


FIG. 8.—The surveying aircraft flies a circular path. Over sea and featureless land Shoran (the short-range radar system developed by R.C.A.) fixes its position at any given time.

FIG. 9.—Flight plan for aerial magnetometer survey.

FIG. 10.—Interior of a D.C.3 plane used for magnetometer survey in the Bahamas.



DISCO

The
detectin
tant ge
uplifts
known
happen
meter
probab
have al
favoura
recently
this des
includin
banks,
involve

The
differen
of the a
meter, e
magnet
magnet
on the
magneti
devices,
aligns it
unit is
350 lb.,
cable at
gamma
stylo pe

The
good ac
point o
time. O
a conti
electric
makes
photos
sea or a
short ra
is illus
Shoran
miles ap
by the a
and at ri
up from
travel 1
knows t
distance

A ver
netomet
centre a
circles d
map is
followin
is actua
position
signal fr
integral
on the
is made
height c
feet) is g

The successful use of the airborne magnetometer in detecting submarines during the last war suggested important geophysical applications to the mapping of basement uplifts or intrusions. If important mineral deposits are known to be associated with the basement rocks which happen to be within mining depths, the airborne magnetometer provides a very quick method in determining the probable extent of these deposits. In oil exploration, we have already seen that a comparatively deep basement is a favourable indication and the airborne magnetometer has recently been used in the Bahama Islands to investigate this desideratum. A total area of over 80,000 square miles, including ocean deeps which lie between the shallow marine banks, was surveyed by this means in seven months; this involved magnetic profiles totalling 54,000 miles.

The airborne magnetometer depends on an entirely different principle from its land counterpart. The motion of the aircraft would prevent readings with a land magnetometer, even assuming an allowance could be made for any magnetic effect of the aircraft itself. In design the airborne magnetometer is complicated, and depends for its success on the fact that it measures changes in the earth's total magnetic intensity in the direction of which, by ingenious devices, the magnetometer unit always automatically aligns itself. To avoid magnetic effects of the aircraft, the unit is housed in a stream-lined case, or 'bird', weighing 350 lb., and towed beneath and behind the aircraft by a cable about 100 ft. long. The sensitivity is as high as one gamma and the variations in the intensity are given by a stylo pen on a moving chart.

The position of the aircraft in space is required with good accuracy and means must exist for referring any point on the magnetic chart to the aircraft's position at the time. Over land, this is achieved by taking air photos with a continuous strip camera. As each photo is taken an electric circuit is actuated, to operate a stylo pen which makes a mark on the magnetic chart. The strip camera photos are later compared with known landmarks. Over sea or a featureless land mass, use is made of Shoran, or short range radar. The plan of operation in the Bahamas is illustrated in Fig. 8. Two boats equipped with Shoran transmitters are stationed at A and B, about 30 miles apart. The exact distance between them is measured by the aircraft which flies several times across the line AB and at right-angles to it. In flight, Shoran signals are picked up from A and B simultaneously and when the combined travel line of the signals is a minimum, the operator knows that the aircraft is on the line AB, and the averaged distance between A and B is easily determined.

A very satisfactory flight plan is one which gives magnetometer profiles along a series of concentric circles with centre at A. (How big the distance is between successive circles depends on whether a regional or detailed magnetic map is required.) The pilot keeps to the circular path by following an indicator on his control panel; this indicator is actuated indirectly by the Shoran signal from A. The position along the circle is given by following the Shoran signal from B, and whenever the distance from B is an integral number of miles, a mark is automatically made on the magnetic chart. An extension of the circular area is made by flying crescent-shaped areas, as shown. The height of the aircraft (a convenient height is 1000–2000 feet) is given continuously by a radio altimeter which is also coordinated with the magnetic chart. With skilful observation and manipulation of the controls, the error in positioning of the aircraft should come within a 'box' of about 100 ft. sides.

In magnetic surveys, a correction must always be made for the daily variation of the earth's magnetic field. A second correction to the magnetic values is due to the regional change of the earth's field, which increases in the direction of either north or south magnetic poles. In the Bahamas this latitude correction is about 8 gammas per mile.

When all the data have been examined and worked on in the office, a magnetic map is drawn and depth estimates to the basement determined. Uplifts in the basement may be in evidence and it is natural to expect that these should show up as 'highs' on the gravity map.

The advantages in undertaking an airborne survey as against a land magnetometer survey are :

(*a*) that small magnetic effects, from magnetised material at depths too shallow to be of geological interest, decrease rapidly with the height of the aircraft so that the magnetic map portrays a picture of the deeper rocks;

(*b*) that maps may be produced from different altitudes of the flight plan, thereby indicating the decrease in the magnetic force with vertical distance and thus facilitating interpretation; and

(*c*) the greater speed and lower cost for areas large in extent.

In the Bahamas as many as fifty technicians were employed in operations affecting the aircraft and magnetometer. These included two crews of five in the aircraft to work a double shift, the ground maintenance staff and the computers and draughtsmen. In addition another twenty men were employed as crews on Shoran boats and a supply boat.

In using the seismic method at sea, the laying-out of the geophones presents the major problem. Cables connecting them to the recording apparatus on board ship must be resistant to salt water, and a speedy method for moving the geophones must be found. The

FIG. 11.—This photograph shows the magnetometer unit in 'bird'.

geophones, themselves waterproof, may be picked up by hand and transported by boat, or dragged along a reasonably smooth sea bed by a tow line. A very quick method is to 'float' each geophone several feet below the surface and above the sea bed by means of a buoy and sinker so that towing becomes a hazardless operation. Present-day developments show a tendency to mount the geophone on gimbals, the whole being housed in a streamlined container; while the geophone cables, of which there may be as many as 24, are tied together along their common lengths. In the reflection method, the dynamite charge rarely exceeds 20 lb., and is often only 5 lb. A curious phenomenon known as the 'bubble effect' occurs whenever an explosion is fired under water. The explosive gases form a bubble which expands rapidly with time; when the pressure inside this bubble becomes less than that in the surrounding water, the bubble starts to contract and continues doing so until the pressure is built up again when a second expansion takes place. The process is repeated a few times until all the energy has been expended, but each time it occurs a seismic wave is propagated outwards and confuses the seismic record of waves received from reflecting formations. To avoid this, the dynamite is fired at such a depth that the first expanding bubble breaks at the surface and there collapses; for charges only a few pounds in weight, this depth is only a few feet.

A seismic reflection party at work in the Bahamas. The small boat (*right*) has laid a charge of dynamite; the launch in the middle has fired it, while the large boat has recorded the energy reflected to a line of geophones laid on the sea bed.

In the refraction method where large charges are required, they must be located about 100 ft. deep for optimum explosive intensity. If this cannot be done owing to limitations in the water depth, much of the energy of the explosion is dissipated in the column of water shot up into the air. The accompanying photograph, which resembles the lower part of the column shot upwards from the Bikini atomic bomb fired under water, was taken about 700 feet away from the explosion of 2 tons of dynamite in 18 ft. of water.

In all geophysical work, the seismic method is the most definitive, and is normally carried out in areas which appear promising from the gravity and magnetic methods. When a dome-shaped formation has been estimated to lie at a depth within drilling limits (which may be 15,000 ft. or more), the next stage in oil exploration is to drill a hole into it. If no oil is found, valuable geological evidence accrues from the various strata drilled through and enables the geologist to decide whether similar dome-shaped formations elsewhere in the general area should be similarly tested. Some years ago it was believed that oil fields could be detected by carrying out delicate chemical analyses of the near surface formations for minute traces of hydrocarbons. Unfortunately, no conclusive evidence exists to support this very attractive geo-chemical hypothesis so that the final arbiter in searching for oil fields is the drill.

JONS JACOB BERZELIUS (1779-1848)

When the chemist of today writes H_2SO_4 or NaCl, he embodies in his work a permanent memorial to Berzelius, the man who dominated chemistry for thirty years before his death on August 7, 1848. For these chemical symbols, the first to come into general use, are (with very few alterations) those which Berzelius introduced in 1819. Dominating chemistry as he did, Berzelius made contributions to almost every major branch of the subject, and his superb experimental skill revolutionised analysis and left a very permanent mark on all subsequent chemistry. His major theories served a purpose in their time, though like nearly every scientific theory which made for progress, they later proved inadequate and passed into the storeroom of history.

Most important of all, his quantitative accuracy put the then young atomic theory on a sound basis. As it left Dalton's hands, the atomic theory was a profound speculation; but, whether one regarded it as a statement about real atoms or (as Davy preferred) a mere statement about combining proportions, it was not of great practical value—for the simple reason that Dalton was not a good enough experimenter to obtain accurate atomic weights. Thus, even when we correct for the fact that he assumed the wrong numbers of atoms in certain molecules, Dalton's weights come out at 14 for oxygen (instead of 16), 100 for silver (instead of 107·88) and 167 for mercury (instead of 200·61). The corresponding numbers which Berzelius had reached by 1826 were oxygen 16, silver 108·3, mercury 202·8—still inaccurate by modern standards, but good enough to turn the atomic theory from a probable truth into a useful tool applicable in all fields of quantitative chemistry. Furthermore, the same accurate methods enabled Berzelius to put on a firm basis the various quantitative laws, and especially the law of multiple proportions, on which the validity of the atomic theory rested.

The other way in which Berzelius can be said to have dominated his times is through his influence on those who flocked to his laboratory in Stockholm to work beside the master. A very large proportion of the great chemists of the next generation spent a year or two in his laboratory gaining a first-hand insight into the meaning of chemical research. Berzelius taught them chiefly by example, but also by precept, which was often embodied in a rather dry irony—as when he commented on hasty work by Wöhler with the brief remark, "Doctor, that was quick but bad". Pupils came to him especially from Germany, and it can be said that the Swede Berzelius was the real founder of the great German chemical school of the middle of the century.

The Hangars Hide Uranium Piles

WILLIAM E. DICK

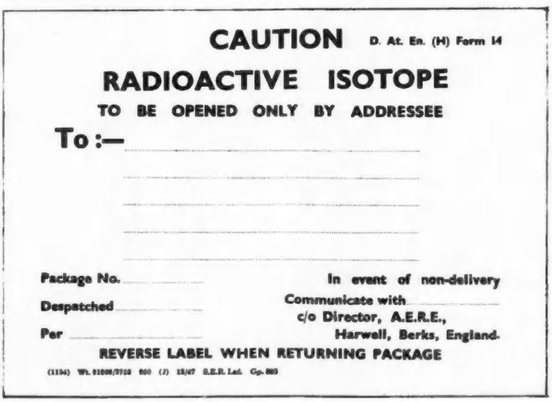
WHILE the coach was taking our party of twenty-five pressmen from Didcot station towards Harwell I could not help recalling what I consider to be the shrewdest comment I've come across upon the social background of modern atomic energy research. It appeared in a leader in the paper I invariably read before Sunday breakfast, and the comment was to the effect that when scientists started research on atomic bombs they took a path which was bound to lead away from the free scientific world in which knowledge knew no national frontiers, a path which was bound to lead, in the absence of international control of atomic energy, into a strange murky country of guarded laboratories and secrecy regulations. There was visible justification for that comment in our first sight of Harwell and the ten-foot high barbed wire fence around the establishment. The first people we met were uniformed War Department Police and plain-clothed security officials of the Ministry of Supply. Throughout the visit they were all to prove extraordinarily helpful, and surprisingly informative; when we arrived, for instance, they seemed to be more concerned that each of us collected our bit of photographic film (which is the visitor's talisman against radiation) than they were with checking the photographs on our identity cards to see that these matched our faces. But no matter how unobtrusively they did their duty and no matter how invaluable they were to us pressmen as guides, one could not help being conscious of the fact that they seemed heavily to outnumber the scientists.

Even the newsreels released after our visit on July 21 brought out that feature of Harwell. But they did not bring out the fact that the most conspicuous human activity on the wind-swept aerodrome which has become the centre of Britain's research on atomic energy is neither that of research or safeguarding secrets but of building. Well over a thousand men are engaged on building work, and the flying dust from the various construction jobs in vigorous progress was virtually the only hazard to health that we encountered. The biggest building jobs in hand were the erection of a radiochemical laboratory and the series of effluent tanks which will hold the waste water so that its radioactive poison can decay before it is piped into the Thames at Sutton Courtenay.

The experience of the scientists of the Chalk River atomic energy plant in Canada (Sir John Cockroft directed Chalk River until he came back to take charge of Harwell, and many of the Harwell staff were trained there too) and the experience gained on the Manhattan Project have gone into the plans for that radiochemical laboratory—Building 220 it is called at the present time—which will be something absolutely unique in Britain. There is nothing particularly unusual about the centre section of this 'hot lab.'—the colloquial term for a laboratory that deals with radioactive chemicals—for this will hold offices. But the wings at either end, in which the dangerous work will be carried out, are most unorthodox. Each wing comprises six 'hot suites' where chemists will separate and analyse the mixtures of radioactive chemicals produced in atomic piles. Each suite contains a 'hot' laboratory where, shielded by walls of lead, the chemists can carry out all the usual chemical procedures with complete safety. Here they will be pipetting liquids, transferring them from one vessel to another, heating solutions, filtering them, in short carrying out the regular routine of manipulations which will differ from those carried out in ordinary chemical laboratories only in so far as they have to be done by remote control, using pneumatic devices, robot hands and so on. The progress of 'hot' reactions will be watched through periscopes. (A limited amount of radiochemical work can be done using nothing more elaborate than a pair of tongs, with which the scientist can handle vessels containing rather weakly radioactive chemicals over the top of a low-walled lead 'castle'.) There is the most elaborate air conditioning in these laboratories, and the whole of the building's upper story is occupied by ducts that change the air in the 'hot' suites about thirty times an hour. Radioactive dusts will be removed by electrostatic precipitators before the air is discharged from the exhaust stack.

This building, like most of the permanent buildings which the scientists are to occupy, is still not complete, though it is well under way. When we visited the radiochemical building the workmen fitting the ducts in the upper story were making the air screech with their hammering and riveting, and others were lining cupboards and fume chambers with huge sheets of lead and handling them with as much abandon as though they were strips of wallpaper.

Most of the scientific work now going on is done in the hangars of this ex-R.A.F. airfield; until Building 220 is ready, the radiochemists work in a converted R.A.F. barrack block. Two hangars hold an atomic pile apiece. We were allowed to examine closely the first of the two piles ever to work in Britain. This is Gleep—the letters stand for Graphite Low Energy Experimental Pile—and it came into operation in August 1947. A cube-shaped


CAUTION D. At. En. (H) Form 14

RADIOACTIVE ISOTOPE

TO BE OPENED ONLY BY ADDRESSEE

To :—

Package No.

Despatched

Per

In event of non-delivery

Communicate with

c/o Director, A.E.R.E.,

Harwell, Berks, England.

REVERSE LABEL WHEN RETURNING PACKAGE

This label is becoming more and more familiar as Harwell's output of radio-isotopes increases.

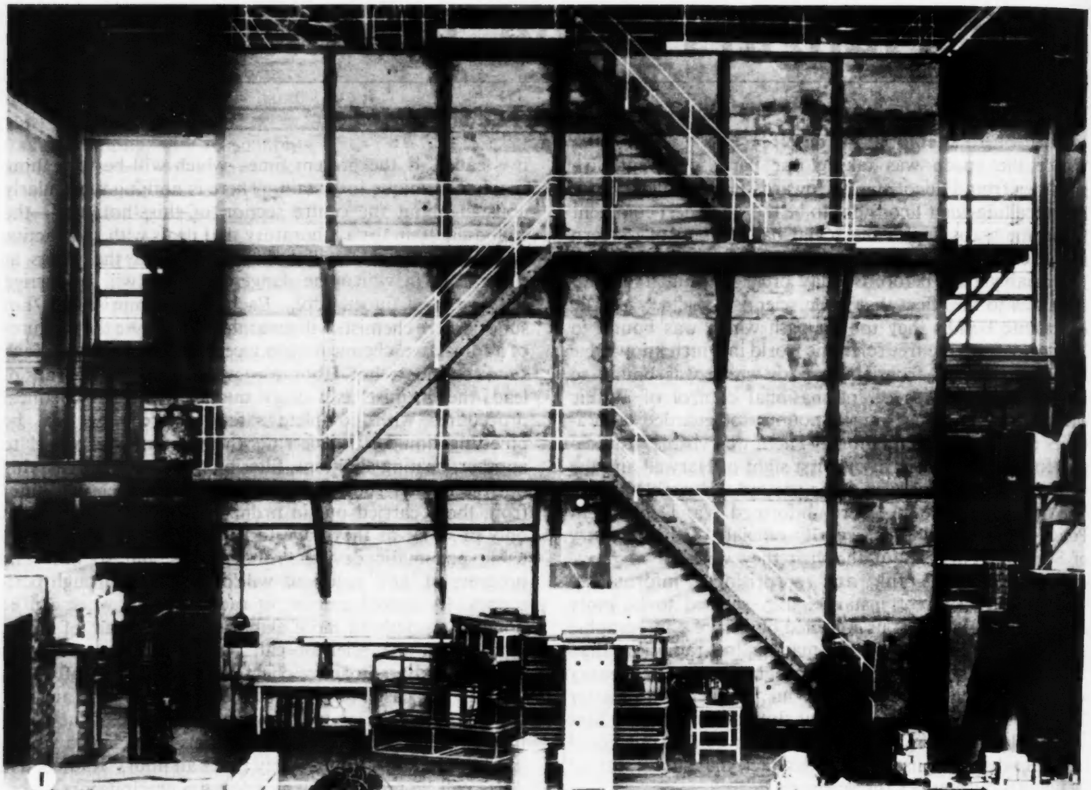
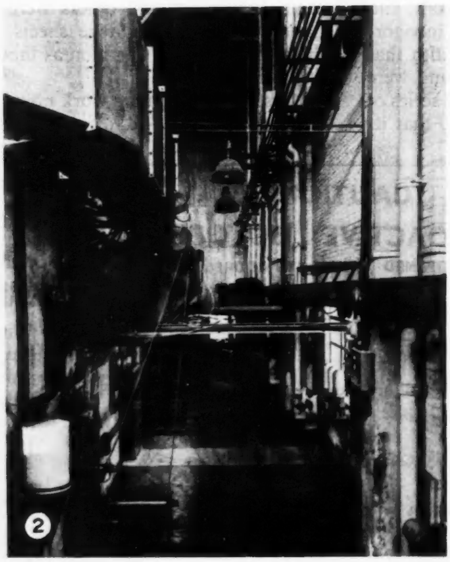
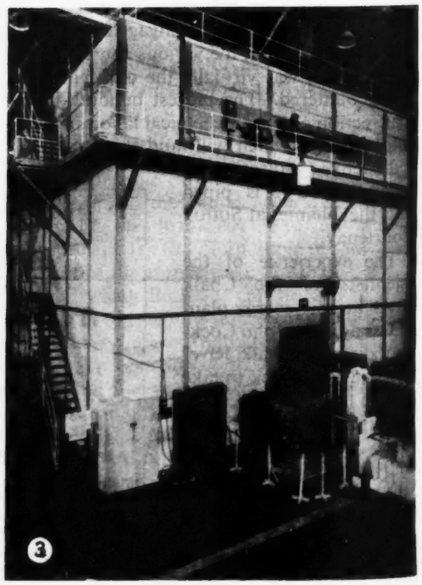


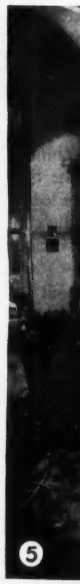
Fig. 1.—In place of the planes that in 1944 carried from Harwell airfield all the paratroops who went to Arnhem stands the accoutrement of modern atomic research. This is Gleep, first atomic pile built in Britain, brought into operation on August 7, 1947. In shape a rough cube and bigger than an average house, it has no special cooling arrangements, cannot with safety be run beyond a power level of 100 kilowatts. A neutron spectrometer is seen in foreground.

Fig. 2.—Gleep's control face. Ionisation chambers for neutron measurements are visible, bottom left. Behind three health monitors on right lies the control room.

Fig. 3.—Samples to be rendered radioactive are inserted in cavities in graphite blocks, which are pushed into the pile through a hole in the concrete shield.







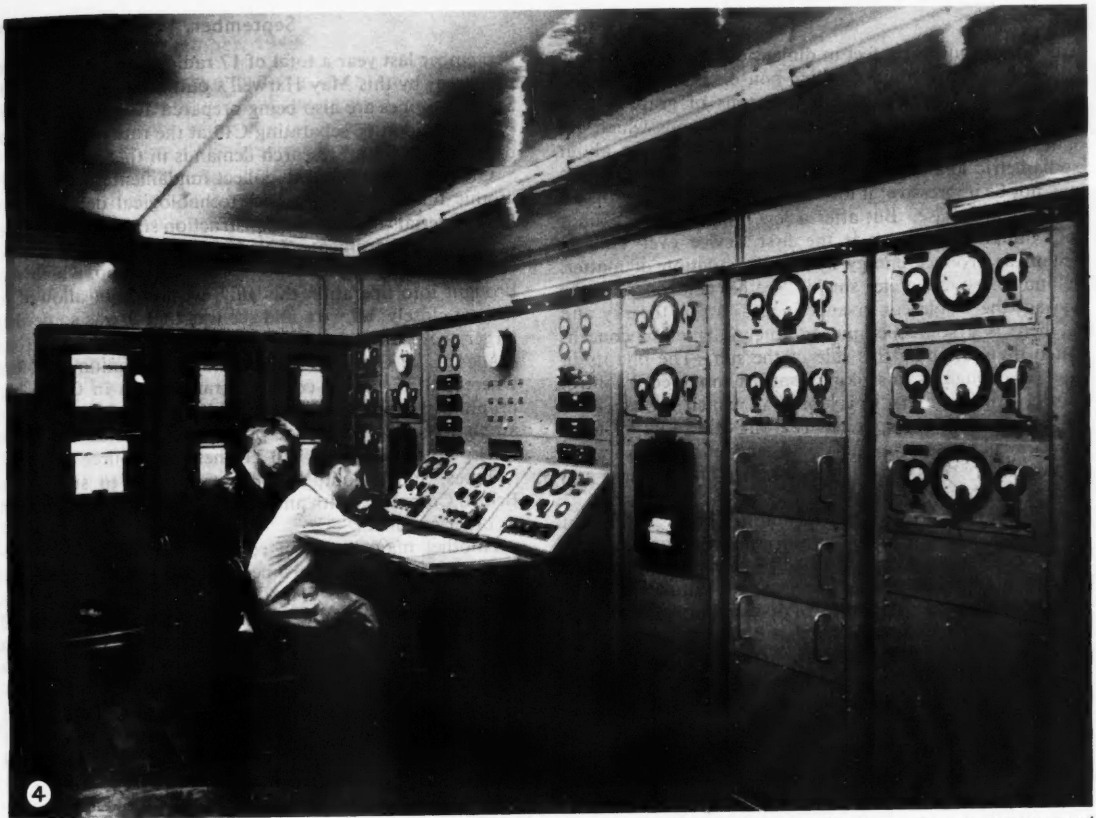


Fig. 4.—Control room for Gleep. Operating details—such as temperature and neutron intensity inside the pile—are automatically recorded. The small current produced when neutrons fall on boron trifluoride in the ionisation chambers (identifiable in Fig. 2 from their resemblance to railway buffers) enables neutron intensity to be recorded electrically here.

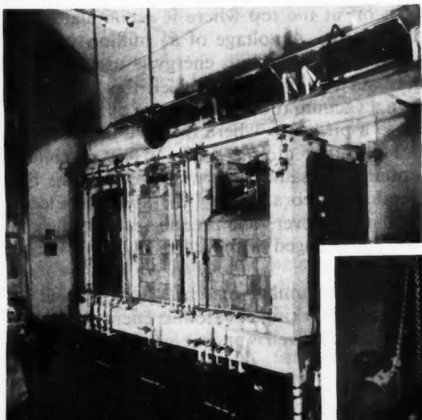


Fig. 5.—In a typical radiochemical laboratory, operators work behind lead-brick walls. Radioactive chemicals are handled by remote control, 'hot' reactions are watched in mirrors.

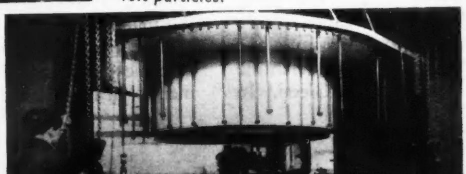


Fig. 6.—Erecting the 110-inch cyclotron magnet.

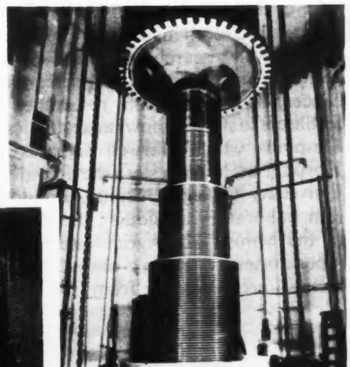


Fig. 7.—Miniaturised Van de Graaff machine gives 5 million-volt particles.

structure, about thirty feet in dimension, it is considerably larger than an average dwelling-house. Behind its thick concrete walls lie several hundred tons of graphite and uranium. The uranium is in the form of rods which are built into a cylindrical lattice, the cylinder being about isodiametric and lying horizontally. First sight of Gleep may not be impressive; it looks a rough affair, rather like a giant packing case. But after a few moments one cannot help thinking that here is the first device ever built in Britain to produce energy by the annihilation of matter. Behind those concrete shields seethe neutrons by the myriad; the whole contrivance is as silent as the sky and yet here is a source of power potentially more concentrated than anything this side of the sun. The pile itself, huge and rough, is in striking contrast to the cool control room, with its great display of dials which show what's happening inside the pile. It is from this room that the pile control rods are automatically moved; from here the vertical safety rods can be made to drop into position and xxtinguish the atomic furnace.

The radio-isotopes which Harwell has been sending out to hospitals and research laboratories during the past year have come from Gleep. In principle their preparation is remarkably simple. Suppose one wants a sample of radioactive phosphorus. A quantity of pure sodium phosphate is taken and inserted into a small aluminium can. Through a tunnel with walls of lead a string (or 'stringer') of graphite blocks can be pushed in and out of the pile, and into a hole machined in one of these blocks the aluminium can is slipped. The stringer is pushed into the pile, and the fierce neutron bombardment inside the pile converts ordinary phosphorus atoms into atoms of radio-phosphorus.

The 'cooking time' varies with the isotope required. For radio-iodine it takes about a fortnight; radioactive sodium and potassium can be made over a week-end, while for radio-sulphur and radio-calcium the time is a month and three months respectively.

I took a look at the despatch book in which consignments of these valuable research tools are listed with no more ceremony than the items in the accounts kept by a milkman or a coal merchant. This showed that most British universities are receiving regular supplies of radio-isotopes for all sorts of research purposes—physical, chemical, agricultural, medical research, researches on heart disease, cancer, pest destruction, researches that will reveal how fertilisers act and how anaesthetics cause their effects. Hospitals which Harwell supplies include the Christie Hospital at Manchester, the Royal Cancer Hospital and University College Hospital, London. The Pest Infestation Laboratory at Slough, the Fisheries Research Centre of the Ministry of Agriculture, the Shirley Institute, the laboratories of Kodak and C.A.V. are other scientific institutions benefiting from the operation of Gleep. In September last year a total of 17 radioactive samples were prepared; by this May Harwell's output had reached 150. Stable isotopes are also being prepared at Harwell; a pilot plant will soon be separating C13 at the rate of 0·3 gram a day, enough for all research demands in this country.

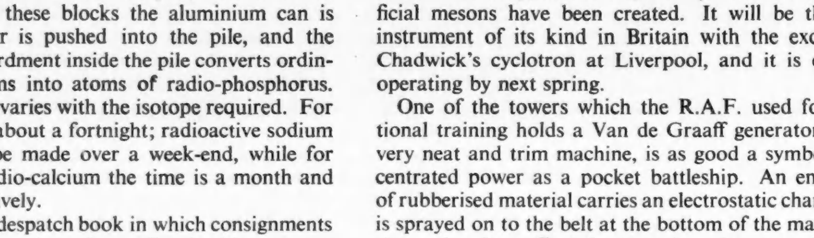
Gleep has been used to collect fundamental facts about atomic nuclei, and to collect technological details about how materials used in pile construction stand up to intense neutron bombardment. This knowledge will be extended considerably now that Bepo is working. Bepo, which was brought into operation this July, we were not allowed to inspect closely; all we could see was that it was somewhat larger than Gleep, and was painted a peculiar heliotrope shade! Like Gleep, Bepo is a graphite-uranium pile, but whereas there are no cooling arrangements in Gleep, the uranium rods in Bepo are cooled by high-speed streams of air that snake through the pile and are ejected up a high stack. In future Bepo will be the main source of radioisotopes, and its output will be sufficient to supply the British Commonwealth and still leave some over for export to other countries.

Another major piece of equipment is Harwell's cyclotron. This monster instrument is installed below ground level inside a hangar. It is a 110-inch machine (that means that the diameter of the magnet poles is 110 inches), and is what is called a synchro-cyclotron, of the same type as the huge 184-inch machine which Prof. E. O. Lawrence built at Berkeley, California, and by means of which artificial mesons have been created. It will be the largest instrument of its kind in Britain with the exception of Chadwick's cyclotron at Liverpool, and it is due to be operating by next spring.

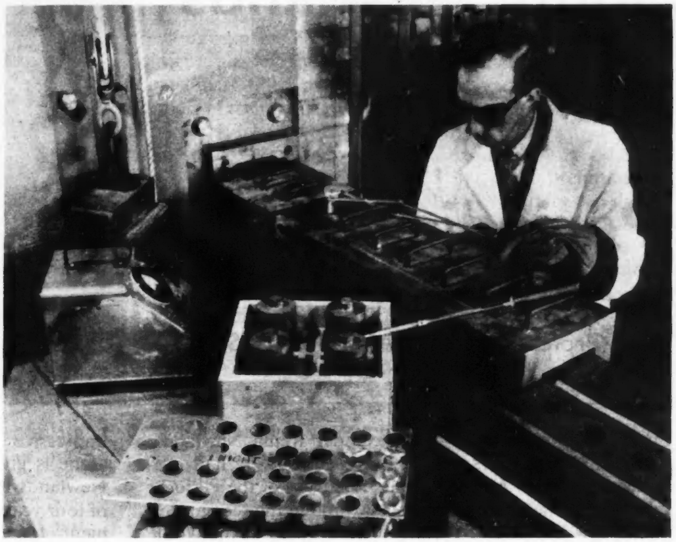
One of the towers which the R.A.F. used for navigational training holds a Van de Graaff generator. This, a very neat and trim machine, is as good a symbol of concentrated power as a pocket battleship. An endless belt of rubberised material carries an electrostatic charge, which is sprayed on to the belt at the bottom of the machine; the charge is taken off at the top where it accumulates on a small round insulator. A voltage of 5½ million volts can be built up, and this tremendous energy is used for firing atomic 'bullets' such as hydrogen nuclei; the 'bullets' are projected down a vacuum tube in the centre of the machine and emerge into a pit below where they are used to study the properties of other atomic nuclei. The machine is built on essentially the same pattern as the machine built for the Cavendish Laboratory by the English Electric Company. It has, however, one unique feature; the conveyor belt can be changed without having to dismantle the machine.

There have been a number of scare stories about the extreme dangers of working in atomic energy establishments. In actual fact Harwell is probably far less dangerous

The Radiochemical Laboratory.



a place to work in than many a chemical factory. The hazards are fully recognised, and the precautions which are taken are in every way adequate. The Medical Research Council has laid down a standard weekly dose of radiation which a worker can receive in safety, and which must not be exceeded. This dose is a very low one, being only half a röntgen a week, which is only half as much as the international standard for X-ray workers. All workers and visitors who may encounter radiation have to carry in their pocket a square of photographic film in lead packing. The workers keep these on their persons for a week, and then the films are collected and sent to the National Physical Laboratory. There they are developed, compared with standard films, and a report goes back to Harwell showing the total amount of radiation each individual worker has received. The medical people keep radiation charts for all the workers, and this is as much a routine record as a hospital temperature chart. Additional check is provided by the small ionisation chambers which certain members of the staff carry in their pockets.



Production of radioactive isotopes in Gleep. The face of the pile is in the background. The sample, in an aluminium container, is placed in a hole in the graphite blocks (*bottom right*) and the latter are pushed in and out of the pile through a hole in the concrete shield. The operator is protected from radiation from the material which has been in the pile by the lead tunnel through which the samples are taken with long-handled tongs. The samples will be placed in the lead pots (*centre*) for transport.

In addition to personnel monitoring, as these precautions are called, there are area surveys. Some of these are done by large monitors or ionisation chambers scattered about the grounds. They record continuously the amount of radioactivity in the air. (In actual fact there has been practically nothing for these to record so far.) Similar monitors are installed in the exhaust stacks of the piles and the radiochemical laboratories. Portable instruments—ionisation chambers and Geiger counters—are carried by the monitoring staff who take check readings in the hangars, for instance, when materials are being withdrawn from the piles.

My inquiry as to the number of scientists working at Harwell was deflected, but ever so politely. The last published figure was given in 1946, when Harwell's staff included 250 scientists. Judging from the number of scientists I met and the amount of work that has been accomplished at Harwell it is quite obvious that the staff must now be at least double that figure.

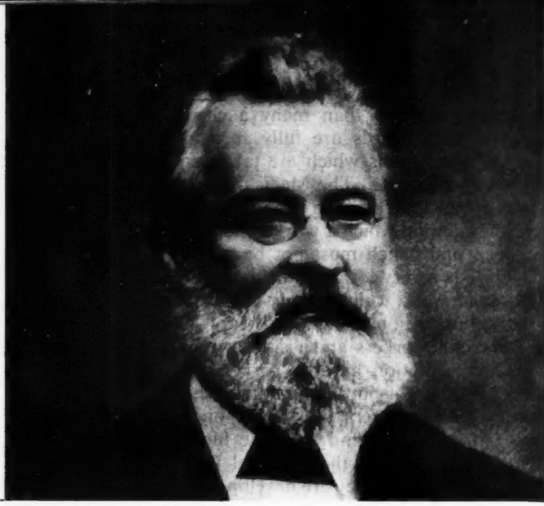
The scientists are organised into various divisions—today there are divisions of Theoretical Physics, Nuclear Physics, General Physics, Chemistry, Chemical Engineering, Metallurgy and Health. Each division is about the size of a large university research school.

Many of the scientists have living accommodation on the site. Sir John Cockroft, for example, lives in what used to be the wing commander's house; his heads of divisions have the houses of the squadron leaders. On the site there are two colonies, each a hundred strong, of aluminium prefabs. Then there are a couple of hundred permanent houses for staff being built at Abingdon, and another two hundred at Wantage.

I started this report with some remarks about secrecy, and in conclusion I should like to qualify those remarks somewhat. It would be wrong to leave readers with the impression that Harwell swarms with security officials; a covey of visiting newspapermen would of course induce an artificial swarm of these conscientious 'secret servants'. Security precautions there have to be; at Harwell they appear to be completely adequate, but they are not excessive and I am quite sure that the average scientist working at Harwell does not find them irksome. Finally, I should like to quote from a document the press was given on the occasion of the visit, which sets out to describe working conditions at Harwell and which, I suspect, corresponds very closely to conditions at Harwell as seen by Sir John Cockroft:

"A comparison is often made between the conditions in which scientists work at universities and at Government research establishments, usually to the disadvantage of the latter. Whatever may be the case elsewhere, this is not a valid criticism of Harwell; a great deal has been done to secure as far as possible a university atmosphere, and though secrecy inevitably surrounds about half the work, there is compensation in the laboratory equipment and workshops facilities that few university workers can hope to enjoy. The Establishment has very close links with the universities, particularly its nearest neighbour, Oxford. Apart from weekly colloquia, many workers at A.E.R.E. are in contact with those in universities engaged in similar fields, and are free to be visited by, and to visit them. Scientific staff are free to publish the results of non-secret work in the technical press, subject to approval by their Division Head and with a minimum of formalities which are dealt with in a few days. Staff are also allowed, within very wide limits, to give lectures to societies by whom they may be approached."

John Newlands and the Periodic System



Professor F. A. PANETH, F.R.S.

FIFTY YEARS AGO died John Alexander Reina Newlands, to whom eleven years earlier the Royal Society had presented their Davy Medal 'for his Discovery of the Periodic Law of the Chemical Elements'. Although the recognition of this law was one of the greatest advances in the whole history of science, one looks in vain for any reference to Newlands in many chemical text-books. The Royal Society itself is not quite free from responsibility if other scientists are given greater prominence in connexion with the Periodic Law, because five years before they gave the Davy Medal to Newlands they had bestowed the same honour on Dmitri Mendeleef and Lothar Meyer 'for their discovery of the periodic relations of the atomic weights', without even mentioning the name of Newlands. Whom shall we then consider as the real discoverer of the Periodic System?

Like many other great achievements, the insight into the mutual relationships of the chemical elements was reached gradually, and a complete historic record would have to name, in addition to Newlands, Mendeleef and Meyer, at least six other chemists—Döbereiner, Pettenkofer, de Chancourtois, Dumas, Odling and Gladstone—and to a certain extent it will always be a matter of opinion whose contribution ought to be considered as the most important one. Not long ago a well-known French chemist, G. Urbain, wrote in one of his books that the Russian Mendeleef—who is usually regarded as the most noteworthy of this whole group of scientists—had done little but extend in a somewhat questionable fashion the fundamental idea of the Frenchman Dumas. Urbain's astonishing attitude will probably be considered by most chemists as an example of misplaced patriotism; while the action of the Royal Society in honouring two foreigners before their own countryman had at least the merit of being dictated by a desire to be absolutely impartial.

As a matter of fact, it is not difficult to understand why Newlands was for a while completely overshadowed by Mendeleef. It is true that he had seen several years earlier than Mendeleef that the most natural grouping of the chemical elements is one based on their atomic weights; he had also come to the correct conclusion that from the conflicting values of atomic weights then in use only those based on the calculations of the Italian chemist Cannizzaro could serve as a reliable basis of such a system; finally, in one paper he had already made an attempt to predict the atomic weight of undiscovered elements—a most impressive undertaking for which usually Mendeleef alone is given credit. But these ideas were published by Newlands in several short papers scattered over a period of four years (1863 to 1866) and showed no steady improvement; for example, the interesting gaps for missing elements just mentioned, which he had left in his 1864 table, were no longer there in the 1866 presentation. When he read this latter paper to the Chemical Society, one of the Fellows suggested that an order according to the initial letters of the elements might give similar regularities. This silly remark has since been quoted again and again as a proof of how far Newlands' colleagues were from grasping the importance of his ideas; but at the same meeting another Fellow of the Society, J. H. Gladstone, made the very judicious criticism that any discovery of a new chemical element, which was by no means unlikely, would destroy Newlands' analogies since in the absence of empty places it would make a complete reshuffle necessary.

When in 1870 Mendeleef's very comprehensive paper appeared and was immediately followed by the long-postponed publication of Lothar Meyer's equally important article, all previous attempts at a systematisation of the chemical elements were quite naturally eclipsed. Nevertheless one must not forget that Newlands was undoubtedly the first who showed that by arranging all known elements in the order of their atomic weights a classification was obtained in which elements of similar properties followed each other at regular distances. As this is the fundamental idea of Mendeleef's and Meyer's Periodic Systems, it is to be regretted that the grant by the Royal Society of the Davy Medal to Newlands came only as a sort of afterthought. On the other hand, most historians of science will subscribe to a pointed remark made by Helmholtz on a somewhat similar occasion; in the course of the dispute about Robert Mayer's share in the discovery of the law of conservation of energy Helmholtz recommended that questions of priority ought to be decided not simply according to the date of the first publication, but that the maturity of the papers should also be taken into account. To a certain extent the action of the Royal Society in honouring first Mendeleef and Meyer can be justified by Helmholtz's argument.

Even after the appearance of Mendeleef's article Newlands returned on several occasions to the problem of the classification of the chemical elements, mainly to

remind chemists of his earlier papers on this subject. He did this always in a very modest fashion, by simply quoting the relevant passages. In 1884 he collected all his contributions to the Periodic System in a little booklet. However, theoretical speculations like these played only a small part in Newlands' professional life; he taught chemistry for a number of years at schools and at the City of London College, was then chief chemist at a sugar refinery (where he was responsible for various improvements in the process), and finally he became an analytical and consulting chemist in independent practice. Together with his brother B. E. R. Newlands, he wrote a *Handbook for Sugar Growers and Refiners*. In his twenties he had fought under Garibaldi for the liberty of a people to which he was related through his mother. His death in 1898, when he was only sixty-one, as the consequence of an attack of influenza, came as a shock to the many friends of this 'kindly courteous man'.

If we want to honour Newlands' memory on the fiftieth anniversary of his death, we can hardly do better than remind readers that his idea of the periodicity of the chemical elements has steadily grown in scientific importance; today not only chemists but also experimental and theoretical physicists are constantly making use of such systematised tables of the elements. We shall, therefore, conclude this article by describing an arrangement which incorporates the latest discoveries.

This will be all the more appropriate as an essential feature of all the modern tables is the assignment of a number to each element; and this is just the one point in which Newlands was in advance even of Mendeleef and Lothar Meyer. Meyer liked to arrange the elements on a continuous curve; this was criticised by Mendeleef because it could mislead one into thinking that there was everywhere room for intermediate elements. Mendeleef's tables with their horizontal and vertical lines made it clear that only a strictly limited number of chemical elements could be placed; but he still ascribed to the actual figures of the atomic weights an exaggerated importance. Newlands, however, used the sequence of the atomic weights only for the purpose of finding the 'ordinal number' of each element, and expressed the 'law of octaves' (i.e. the periodicity) in terms of these ordinal numbers; in 1866 his table ended with element No. 56, in 1875 with No. 63. These tables in which prominence is given to the numbers of the elements, not to their weights, look astonishingly modern; it was not before 1897 that ordinal numbers were again introduced in the Periodic System by Rydberg; but only after 1913, when the Rutherford-Bohr theory of the atom had been developed, the deep physical significance of these ordinal numbers, now usually called atomic numbers, could be understood; they represent the number of positive electric charges of the atomic nuclei. In giving them prominence over the atomic weights Newlands had been guided by a remarkably sure instinct.

Tables of the Periodic System are so well known that only a few explanatory remarks seem necessary for the two given here. They concern the elements Technetium, Promethium, Astatine, Francium, Neptunium, Plutonium, Americium and Curium, which are still missing in most tables available today but which have been included in ours.

If we look at a table of the Periodic System drafted a few years ago, we shall find that the last element shown in it, uranium, has the number 92, but that to several previous numbers no element has been assigned. The most correct tables left the places 43, 61, 85 and 87 empty while some others filled one or two of the vacancies with the symbols of spurious discoveries. According to our present-day knowledge, the position is briefly as follows.

The discovery of element 43 was claimed by Noddack, Tacke and Berg in Berlin in 1925, but their preliminary announcement was never followed up by a more convincing paper; nevertheless the proposed name masurium (symbol Ma), derived from Germany's eastern province, was put into many tables. So far the element 43 has not been found in any naturally occurring mineral, but it was artificially produced by Perrier and Segrè in 1937 by bombarding element 42, molybdenum, with deuterons or with neutrons in the cyclotron. Another method for obtaining element 43 is the fission of uranium, in the course of which all the elements between No. 30, zinc, and No. 63, europium, are formed in different amounts. Today several isotopes of 43 are known; the most stable one has a half-life of 4×10^6 years and an atomic weight of 99. Perrier and Segrè suggested for element 43 the name technetium (symbol Tc), because of its artificial production.

The story of the discovery of element 61 is very similar to that of 43. In 1926 Harris, Yntema and Hopkins, of the University of Illinois, believed they had found it among other rare earths, and the name illinium (symbol Il) proposed by them in honour of their state was widely accepted; but they were unable to substantiate their claim, and a very careful search by the greatest authority in the field of rare earth chemistry, the Austrian industrialist Auer von Welsbach, proved that the element to be expected between neodymium and samarium does not exist in the minerals in which the presence of illinium had been announced. However, as stated before, it is formed as one

To the Editor of the CHEMICAL NEWS.

SIR,—With your permission, I would again call attention to a fact pointed out in a communication of mine, inserted in the CHEMICAL NEWS for August 20, 1864.

If the elements are arranged in the order of their equivalents, with a few slight transpositions, as in the accompanying table, it will be observed that elements belonging to the same group usually appear on the same horizontal line.

	No.		No.		No.		No.		No.		No.		No.		No.
H	1	F	8	Cl	15	Co & Ni	22	Br	29	Pd	36	I	42	Pt & Ir	50
Li	2	Na	9	K	16	Cu	23	Rb	30	Ag	37	Cs	44	Tl	53
G	3	Mg	10	Ca	17	Zn	25	Sr	31	Bd	38	Ba & V	45	Pb	54
Bo	4	Al	11	Cr	19	Y	24	Ce & La	33	U	40	Ta	46	Th	56
C	5	Si	12	Ti	18	In	26	Zr	32	Sn	39	W	47	Hg	52
N	6	P	13	Mn	20	As	27	Di & Mo	34	Sb	41	Nb	48	Bi	55
O	7	S	14	Fe	21	Se	28	Ro & Ru	35	Te	43	Au	49	Os	51

(NOTE.—Where two elements happen to have the same equivalent, both are designated by the same number.)

It will also be seen that the numbers of analogous elements generally differ either by 7 or by some multiple of seven; in other words, members of the same group stand to each other in the same relation as the extremities of one or more octaves in music. Thus, in the nitrogen group, between nitrogen and phosphorus there are 7 elements; between phosphorus and arsenic, 14; between arsenic and antimony, 14; and lastly, between antimony and bismuth, 14 also.

This peculiar relationship I propose to provisionally term the "Law of Octaves." I am, &c.

JOHN A. R. NEWLANDS, F.C.S.

Laboratory, 19, Great St. Helen's, E.C., August 8, 1865.

Newlands' 'Law of Octaves' as published in a letter to *Chemical News*, 18th August, 1865.

TABLE I.—SHORT-PERIOD SYSTEM OF THE CHEMICAL ELEMENTS

Period	Group I a b	Group II a b	Group III a b	Group IV a b	Group V a b	Group VI a b	Group VII a b	Group VIII a	b
I							1 H 1·0080		2 He 4·003
II	3 Li 6·940	4 Be 9·02	5 B 10·82	6 C 12·010	7 N 14·008	8 O 16·0000	9 F 19·00		10 Ne 20·183
III	11 Na 22·997	12 Mg 24·32	13 Al 26·97	14 Si 28·06	15 P 30·98	16 S 32·066	17 Cl 35·457		18 A 39·944
IV	19 K 39·096 29 Cu 63·54	20 Ca 40·08 30 Zn 65·38	21 Sc 45·10 31 Ga 69·72	22 Ti 47·90 32 Ge 72·60	23 V 50·95 33 As 74·91	24 Cr 52·01 34 Se 78·96	25 Mn 54·93 35 Br 79·916	26 Fe 27 Co 28 Ni 55·85 58·94 58·69	36 Kr 83·7
V	37 Rb 85·48 47 Ag 107·880	38 Sr 87·63 48 Cd 112·41	39 Y 88·92 49 In 114·76	40 Zr 91·22 50 Sn 118·70	41 Nb 92·91 51 Sb 121·76	42 Mo 95·95 52 Te 127·61	43 Tc 99 53 I 126·92	44 Ru 45 Rh 46 Pd 101·7 102·91 106·7	54 Xe 131·3
VI	55 Cs 132·91 79 Au 197·2	56 Ba 137·36 80 Hg 200·61	57–71 Rare Earths† 81 Tl 204·39	72 Hf 178·6 82 Pb 207·21	73 Ta 180·88 83 Bi 209·00	74 W 183·92 84 Po 210	75 Re 186·31 85 At 211	76 Os 77 Ir 78 Pt 190·2 193·1 195·23	86 Rn 222
VII	87 Fr 223	88 Ra 226·05	89 Ac 227	90 Th 232·12	91 Pa 231	92 U 93 Np 94 Pu 95 Am 96 Cm 238·07 237 239 241 242			

† Rare Earths

VI 57–71	57 La 138·92	58 Ce 140·13	59 Pr 140·92	60 Nd 144·27	61 Pm 147	62 Sm 150·43	63 Eu 152·0	64 Gd 156·9	65 Tb 159·2	66 Dy 162·46	67 Ho 164·90	68 Er 167·2	69 Tm 169·4	70 Yb 173·04	71 Lu 174·99

TABLE II.—LONG-PERIOD SYSTEM OF THE CHEMICAL ELEMENTS

Period	Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
I																	1 H 1·0080	2 He 4·003
II	3 Li 6·940	4 Be 9·02											5 B 10·82	6 C 12·010	7 N 14·008	8 O 16·0000	9 F 19·00	10 Ne 20·183
III	11 Na 22·997	12 Mg 24·32											13 Al 26·97	14 Si 28·06	15 P 30·98	16 S 32·066	17 Cl 35·457	18 A 39·944
IV	19 K 39·096	20 Ca 40·08	21 Sc 45·10	22 Ti 47·90	23 V 50·95	24 Cr 52·01	25 Mn 54·93	26 Fe 55·85	27 Co 58·94	28 Ni 65·69	29 Cu 63·54	30 Zn 65·38	31 Ga 69·72	32 Ge 72·60	33 As 74·91	34 Se 78·96	35 Br 79·916	36 Kr 83·7
V	37 Rb 85·48	38 Sr 87·63	39 Y 88·92	40 Zr 91·22	41 Nb 92·91	42 Mo 95·95	43 Tc 99	44 Ru 101·7	45 Rh 102·91	46 Pd 106·7	47 Ag 107·880	48 Cd 112·41	49 In 114·76	50 Sn 118·70	51 Sb 121·76	52 Te 127·61	53 I 126·92	54 Xe 131·3
VI	55 Cs 132·91	56 Ba 137·36	57–71 Rare Earths†	72 Hf 178·6	73 Ta 180·88	74 W 183·92	75 Re 186·31	76 Os 190·2	77 Ir 193·1	78 Pt 195·23	79 Au 197·2	80 Hg 200·61	81 Tl 204·39	82 Pb 207·21	83 Bi 209·00	84 Po 210	85 At 211	86 Rn 222
VII	87 Fr 223	88 Ra 226·05	89 Ac 227	90 Th 232·12	91 Pa 231	92 U 238·07	93 Np 237	94 Pu 239	95 Am 241	96 Cm 242								

† Rare Earths

VI 57–71	57 La 138·92	58 Ce 140·13	59 Pr 140·92	60 Nd 144·27	61 Pm 147	62 Sm 150·43	63 Eu 152·0	64 Gd 156·9	65 Tb 159·2	66 Dy 162·46	67 Ho 164·90	68 Er 167·2	69 Tm 169·4	70 Yb 173·04	71 Lu 174·99

Copies of the above tables printed on card ($3\frac{1}{2}$ in. × 5 in.) and punched for insertion in loose-leaf notebooks may be obtained from the publishers (Jarrold & Sons, Ltd., Norwich), price 6*d.* each table, post free.

of the many fission products of uranium and was isolated and identified by Marinsky and Glendenin who worked during the recent war on atomic energy problems in the team of Professor Coryell of the Massachusetts Institute of Technology. One isotope of element 61 with atomic weight 147 is fairly long-lived; its half-life is 3·7 years. Marinsky and Glendenin recommended the name Promethium (symbol Pm), the allusion being that just as Prometheus brought fire from the heavens to earth, science has now succeeded in harnessing for the use of mankind another cosmic force, atomic energy.

Element 85 seems to exist as a rare branch product in the natural radioactive series; but its preparation and chemical study was only possible after one of its isotopes had been artificially made by the bombardment of bismuth with alpha-rays. The credit for this achievement goes to Corson, MacKenzie and Segrè; they put forward the name astatine (symbol At), with reference to the instability of the new element (the Greek 'astatos' meaning 'unstable'). The half-life is only 7·5 hours; the atomic weight is 211.

Element 87 was discovered in 1939 by Mlle Perey in Paris as a minor disintegration product in the actinium series, and has also been artificially produced from heavier elements. Its name will be francium (symbol Fr). The natural product has the atomic weight 223 and is very short-lived, its half-life being only 21 minutes.

The extensive study of the behaviour of element 92, uranium, under bombardment with neutrons and other particles has led to the discovery that several elements with ordinal numbers higher than 92 can be obtained which do not exist on the Earth. So far four of these 'trans-uranium' elements have been identified; their proposed names and symbols as well as the atomic weights and half-lives of their most stable isotopes are as follows:

Atomic No.	*Name*	*Symbol*	*Atomic weight*	*Half-life*
93	Neptunium	Np	237	$2{\cdot}25 \times 10^6$ yrs
94	Plutonium	Pu	239	$2{\cdot}4 \times 10^4$ yrs.
95	Americium	Am	241	500 yrs.
96	Curium	Cm	242	150 days

The names of the first two elements after uranium are taken from Neptune and Pluto, the planets beyond Uranus in the Solar System; as no planet beyond Pluto is known the names of elements 95 and 96 have been chosen for their geographical and personal connotations. The discoverers of these four new elements are McMillan, Seaborg, and several other American physicists and chemists who have been working with them in the universities of California and Chicago.

The eight new element names mentioned have not yet been officially sanctioned, and in view of a few rival claims (especially for element 61) it may still be some time before an international agreement is reached. It seems, however, not unsafe to predict the eventual acceptance of the names given above, and we have, therefore, inserted their symbols in our tables.

Innumerable forms of the Periodic System have been tried since the days of Newlands, Meyer and Mendeleef, but we believe that all real advantages of any of these diverse attempts are incorporated in one or other of two comparatively simple tables. The first is the usual 'Mendeleef table', somewhat modernised; the fundamental idea of the second table has occurred from time to time independently to a number of chemists and it goes, therefore, under different names, but is, in fact, to be found already in Mendeleef's earliest publications as an alternative. We prefer, therefore, to distinguish the two basic forms as the 'short-period table' and the 'long-period table'. The first is especially useful to demonstrate the valency regularities of the chemical elements and is, therefore, favoured in chemistry text-books; the latter is frequently more suitable for discussions on subjects of theoretical physics. We recommend having both simple tables at hand, and not to bother with complicated schemes which try to unite the specific advantages of the short- and the long-period representations with the help of elaborate geometrical designs, colours, movable parts, or steric models.

A final word may be said about the way in which we have placed the trans-uranium elements. From their chemical behaviour it must be concluded that they are not higher homologues of the elements rhenium, osmium, iridium and platinum, but all very similar to uranium. We have, therefore, not assigned them to definite places under the elements 75 to 78 but have written them as a continuous group together with uranium. This is similar to the treatment of the rare earth elements, which however, for reason of space, are taken out of the framework of the table altogether and written as a coherent group, beginning with lanthanum, at the bottom. It ought to be mentioned that for theoretical reasons, Professor Seaborg believes that it is justified to speak of a second rare earth group which begins already with element 89, actinium, and extends at least as far as element 96, curium; he calls elements 89 to 96 the 'actinide series', just as the elements 57 to 71 are often named, after their first member, the 'lanthanide series', and he recommends writing both groups in parallel lines at the bottom of the Periodic Table. However, it seems to us that the similarity between the elements of the so-called actinide series is not nearly great enough to justify this comparison with the rare earth group, and that it would be a mistake to obscure the obvious correspondence between actinium and lanthanum, thorium and hafnium, protactinium and tantalum, uranium and tungsten. For instance, the increase in the maximum valency from three to six is as regular if we pass from actinium to uranium as it is from lanthanum (and the other rare earths) to tungsten; this and other valuable information embodied in the traditional form of the Periodic Table would be lost if we were to isolate elements 89 to 92 as members of a second rare earth group. For this reason the arrangement in our tables of the elements 89 to 96 differs from that adopted recently in several publications by Seaborg and others.

READING LIST

Obituary note on John A. R. Newlands, *Nature*, 1898, Vol. 58, 395.

G. T. Seaborg, The Transuranium Elements, *Science*, 1946, Vol. 104, 379.

G. T. Seaborg, Plutonium and other Transuranium Elements, *Chemical and Engineering News*, 1947, Vol. 25, 358.

F. A. Paneth, Radioactivity and the Completion of the Periodic System, *Nature*, 1942, Vol. 149, 565.

F. A. Paneth, The Making of the Missing Chemical Elements, *Nature*, 1947, Vol. 159, 8.

New Birds in Britain

R. S. R. FITTER

WHAT is a British bird, and how many of them are there? The most recent authoritative answer is to be found in the monumental *Handbook of British Birds*, completed in 1941, where 424 species and 96 subspecies are admitted as having been reliably recorded at least once in the British Isles in historic times. One of these, the Great Auk, is extinct (so, possibly, are two vagrants, the Capped Petrel and the Eskimo Curlew), and of the remainder 26 species are the veriest vagrants, having occurred once only. In all there are only some 250 species which occur at all regularly in the British Isles, and 65 of these are purely winter visitors or passage migrants. It is the 185 species which breed regularly in the British Isles that can claim to be British birds in the truest sense; 133 are residents and the rest summer visitors. Any increase or decrease in their numbers is therefore watched jealously by British ornithologists for sentimental as well as scientific reasons.

It is now generally realised that all animal populations are in a state of continuous flux, even when apparently stable, and the bird population of the British Isles is no exception. In a recent review of the changes in status of British breeding birds since 1840, W. B. Alexander and David Lack showed that (omitting introduced and sporadic breeding species) only 30 per cent showed no evidence of marked change in status, and that some of these had changed locally or moderately or in short-term fluctuations. Here I propose to deal only with the gains and losses among the breeding species since 1900, with some brief references to those birds which have bred sporadically in the present century, and which may therefore become permanent breeding species at some later date. It must be borne in mind, however, that these absolute gains and losses are only part of a pattern of which the widespread increases of such species as the Fulmar and Great Black-backed Gull and decreases of others, such as the Wryneck and Corncrake, form a larger and perhaps more significant part.

E. M. Nicholson in *Birds in England* (1926) has shown that from the beginning of written records down to 1900 fourteen birds were lost as British breeding species, and ten gained. Since 1900 we have lost two more, but gained six, including two species lost in the earlier period. The species lost before 1900, in roughly the chronological order of their disappearance, were the Crane, Spoonbill, Capercaillie (native Scottish form), Goshawk, Whooper Swan, Great Bustard, Great Auk, Avocet, Black-tailed Godwit, Savi's Warbler, Bittern, Honey-Buzzard and Ruff. Since the turn of the century the Osprey and the White-tailed Eagle have gone too. To balance these losses, by 1900 we had already acquired, largely as a result of deliberate human introduction, the Pheasant, Canada Goose, French or Red-legged Partridge, Capercaillie (Swedish form, reintroduced to Scotland about 1837), Tufted Duck, Wigeon, Gadwall, Pintail, Goosander and Little Owl. Within the past fifty years the Bittern and Whooper Swan have returned, and the Slavonian and Black-necked Grebes, Black Redstart and Little Ringed Plover have arrived. There are also a number of species which for various reasons it is difficult to put on one side or other of a balance sheet, such as the Golden Oriole, Crossbill, Hoopoe, Marsh-Harrier, Honey-Buzzard, Kentish Plover and Spotted Crake, and yet others which either because they are very local as breeding species or for other special reasons must be regarded as rather bad bets for inclusion in the list of British breeding birds in 1948. This last group includes the Crested and Bearded Tits, Dartford Warbler, Hen-Harrier, Kite and Whimbrel.

The only two casualties of the twentieth century, the Osprey and the White-tailed or Sea-Eagle, are both birds of prey which to some extent compete with sportsmen, and so have been persecuted by gamekeepers and water-bailiffs, the *coup de grâce* being perhaps administered by the egg-collector. The Osprey once bred on many Scottish lochs, but by the end of the last century was already on the verge of extinction. The historic eyrie on the ruined castle in Loch an Eilein near Aviemore, often pillaged by egg-thieves, was last occupied in 1899, though a single bird lingered for three more years; the eyrie on Loch Arkaig, Inverness-shire, was last occupied in 1908, though again a single bird stayed two years longer; finally we have the authority of the Professor of Zoology at the University of Edinburgh for the statement that a pair bred somewhere in Scotland in 1916. Apart from this, the authors of the *Handbook* can only say, "there is evidence of breeding at Loch Luichart (Ross-shire) and elsewhere on occasions since, but we have not definite proof of this".

The Sea-Eagle also perished as a British breeding bird in the opening decade of the present century. In Scotland the last pair bred in the Shetlands till 1908, when the male was shot; the female brooded the empty nest each year till 1918. The last of the Irish Sea-Eagles vanished some years before 1911. There have been many rumours of the occasional breeding of both the Sea-Eagle and the Osprey in the British Isles in the past thirty years, but none have been substantiated.* There is a regular passage of Ospreys through Britain in both spring and autumn, and no doubt some of the rumours have originated in passage birds staying longer than usual at some favourite loch. The Sea-Eagle is much scarcer on migration, and occurs chiefly in autumn, when the young birds pass through in a plumage lacking the white tail which renders them liable to confusion with adult Golden Eagles—to add to the muddle the immature Golden Eagles passing through at the same time do have white tails.

There are two or three other birds which would probably have to be put in the category of lost if we had the full facts about them. Among them is the Kentish Plover, which seems always to have been confined as a British breeding species to the shores of the extreme south-east of England, and in particular the great shingle beach of Dungeness. According to the *Handbook*, the Kentish Plover has not bred regularly on Dungeness since 1931, but may still do so in two other Kentish localities. It has not been known to breed in Sussex for twenty-five years.

* Since writing this I have seen a statement by Dugald MacIntyre that a pair of ospreys nested on a loch in the north of Scotland in 1947.

FIG. 1.—Little Ringed Plover. (*Photo by M. D. England.*)

FIG. 2.—Bittern with egg and young. (*Photo by Eric Hosking.*)

FIG. 3.—Cock Slavonian Grebe, displaying on nest. (*Photo by Eric Hosking.*)

FIG. 4.—Black-winged Stilt. (*Photo by G. K. Yeates.*)

Since the publication of the *Handbook* breeding records for Dungeness in 1942 and 1943 have been announced, but these are the only recent published ones. If it still breeds elsewhere in Kent, the secret is being well kept, but it is more than likely that no news here means bad news. The cause of the decline we can only guess; the small English colony has always been on the very edge of the species's range, and some slight adverse change in natural conditions may have tilted the balance against it.

The Spotted Crake is another bird of whose breeding status in Britain we are almost wholly ignorant, largely owing to the inaccessibility of the marshy nesting grounds which it favours. The authors of the *Handbook* knew of only four nests found in the British Isles in the decade 1931–40, and it seems clear that it is much less common than in the nineteenth century. Probably it is not yet to be counted among the lost British breeding birds, but in another ten or twenty years it may well have to be.

The brighter side of the picture is illustrated by the return of the Bittern and its re-establishment as a breeding species in East Anglia (Fig. 2). At one time the Bittern bred regularly in many parts of England, Wales—its Welsh name is *bwmp y gors*, the boom of the marsh—Ireland and southern Scotland, but it died out everywhere during the early part of the last century. It survived longest in Norfolk, where a pair bred as late as 1868 and young were found in down in 1886. Since 1911, when Miss Turner and Jim Vincent found a young bird in the Norfolk Broads, the Bittern has steadily regained lost ground, till now it nests on many large areas of marsh in Norfolk, Suffolk and Cambridgeshire, and within the past few years is believed to have begun to breed in two quite different areas, one in the north of England and the other in the south. Since there is now less marshland suitable for Bitterns than eighty years ago, the successful return of this species suggests that while the extensive draining of marshes was undoubtedly an important contributory factor in its original disappearance, there must also have been some other factor involved, such as human persecution or a natural downward fluctuation in the whole population. There is, therefore, every reason to hope that other marshland birds, notably the Black-tailed Godwit, Ruff, Avocet and Black Tern, whose extinction was originally attributed almost wholly to the draining of the marshland, may yet return to breed regularly, more especially as they all occur regularly on passage. Since Savi's Warbler has not even been seen on migration in this country for over thirty years, its return seems less likely.

The other bird which has returned is the Whooper Swan, which bred in the Orkneys in the eighteenth century. Published references to its present breeding status in Scotland are few and advisedly vague, but it appears to have nested first in western Perthshire about 1918, and elsewhere in the Highlands since. In 1928 a pair attempted to nest in Norfolk. There seems no reason why the Whooper should not make a welcome addition to our breeding birds over a wide area in Scotland.

The Honey-Buzzard has a rather slight claim to be included under the heading of returned birds. Since it ceased to breed regularly about 1870 many scattered nests have been recorded; a pair bred, for instance, near the Welsh border every year from 1928 to 1932. It cannot yet be regarded, however, as other than a sporadic breeder in Britain.

There are two grebes in the list of new breeding species since 1900, though it is quite likely that one or both bred undetected at any rate sporadically in earlier years. Clark Kennedy's statement in 1868 that the Black-necked Grebe had bred at Tring Reservoirs, Hertfordshire, was scouted at the time, yet pairs bred or were present in this very locality in most years between 1918 and 1930. The fact that an unsuspected colony of 250 pairs of this species could be discovered in Co. Roscommon in 1930 makes it quite likely that colonies existed in the nineteenth century but were never found. The Black-necked Grebe was first known to breed in the British Isles in Anglesey in 1904, and was then thought to have been present in previous years. During the past forty years it has bred sporadically, and rarely for long on any one water, in many parts of the British Isles, most regularly in certain Scottish lochs. Whereas the Black-necked Grebe is a southern species spreading northward, the Slavonian Grebe is a northern species extending southward, and has bred on several lochs in Inverness and other Scottish counties since about 1908 (Fig. 3).

The two most striking examples of birds colonising the British Isles in the past fifty years without direct human aid are undoubtedly the Black Redstart and the Little Ringed Plover (Fig. 1). In 1906 Warde Fowler observed that "why the black redstart should breed regularly within 65 miles of our coast and never cross the Channel for the purpose is indeed a mystery". Actually the first breeding record for the Black Redstart, which has only quite recently been authoritatively substantiated (the nest and eggs having been preserved in the Hancock Museum, Newcastle-on-Tyne) was for Durham in 1845. This was an isolated case, but within three years of Warde Fowler's remark a pair nested on the Sussex coast, forerunners of the present wave of invaders. This again was not known until quite recently: for many years it was believed that the pair found breeding on the Sussex coast in 1923 by S. D. Herington (and published over the name of T. A. Coward to preserve the secret) was the first to do so in Britain. Three years later E. M. Nicholson was emboldened to prophesy that within a few years the Black Redstart would rank among the regular British breeding species. In point of fact we now know that the bird has bred somewhere in England in every year since 1923. Three pairs nested on the same beam every year from 1926 to 1941 in the Palace of Engineering at Wembley, and were only disturbed by increasing industrial activity, while one or more pairs nested in Cambridge for several years from 1936 onwards. From 1936 also Black Redstarts began to frequent the centre of London with increasing regularity, until in 1940 a pair nested within the precincts of Westminster Abbey. The bird has bred in central London in every year since, several pairs being usually present. Its headquarters are a large open blitzed area of the City—a Black Redstart territory in London in fact must be valued at hundreds of thousands if not millions of pounds. Similar conditions have led the bird to colonise Ramsgate, Dover, Hastings and other south-eastern coastal towns.

The arrival of the Black Redstart on the shores of England is the culmination of a long-term spread of the species over north-western Europe during the past 150

years, though it has doubtless been accelerated during the past eight years by the provision of an abundance of suitable nesting sites as a result of the bombing. However, both on the Continent and in Cambridge before the war the bird found suitable holes and crevices in buildings without such adventitious aid. The presence of an area of rubbly ground to feed on is perhaps more important than a cranny or ledge for the nest. The Black Redstart has always been partial to such broken ground as brickfields, graveyards and the detritus at the foot of cliffs, while in London before the war it was usually associated with vacant building sites, such as those around the new Westminster Hospital and London University buildings.

The spread of the Little Ringed Plover is both more recent and more unexpected. The first-known pair bred at Tring Reservoirs in 1938, at a time when the bird had been recorded on only fourteen previous occasions in the British Isles, the latest being in Sussex in May 1922. Then a lapse of six years occurred, during which a few odd birds were seen in various parts of south-west England, before the next breeding record. In 1944 two pairs returned to Tring (thanks to the large number of bird-watchers who visit these reservoirs it is about as certain as anything can be in ornithology that none bred there in the intervening years), and a third pair was found at a gravel-pit in Middlesex. Since then the bird has greatly increased in the London Area, breeding almost invariably at gravel-pits, usually working ones. In 1947 some dozen pairs were known within twenty miles of Charing Cross, eight nests being found and four other broods located. The reason for the almost exclusive confinement of the Little Ringed Plover to the London area during the breeding season seems to be the large number of gravel-pits found in the valleys of the Thames, Colne and Lea, many of which have the small artificial beaches of which the bird seems especially fond. The natural habitat of the Little Ringed Plover, which breeds just across the Channel in France, Belgium and Holland, consists of sandy or shingly banks in rivers or on the shores of freshwater lakes.

The Crossbill has some claim to be classed as a new British breeding bird. It is one of those species which every few years irrupt westwards from the north and east of Europe into the British Isles (the Waxwing and Pallas's Sand-Grouse are other examples), and after every large invasion a few pairs stay to breed. Nowhere, however, have they ever succeeded in establishing themselves, with the exception of the Breckland of Norfolk and Suffolk, which was colonised after the great irruption of 1910. Even here, however, they have been declining of late years, and it is doubtful if they can maintain themselves indefinitely without an influx of fresh blood. This southern breeding colony of Crossbills is, of course, of the continental subspecies. There is also a native Scottish crossbill, assigned by systematists to separate sub-specific rank on account of its larger bill, which is resident in the Spey Valley and elsewhere in the Highlands.

The Golden Oriole and the Hoopoe are two rather difficult cases. Both have been sporadic breeders in southern England for as long as we have records, though there are indications that they have become somewhat scarcer over the past fifty years. The case of the Marsh-Harrier is different again. Once widespread in suitable marshy areas—around 1810 the Old Kent Road was a noted locality for it!—the bird ceased to nest throughout the British Isles except in Norfolk and Ireland by the turn of the century, and it has not been known to nest in Ireland for over thirty years. In Norfolk, however, the continuity never seems to have been wholly lost, though in many years no young were reared, and a few pairs now breed with fair regularity in the Broads. Within very recent years there has been a welcome sign of the bird spreading, and breeding has been proved in North Wales and suspected in two other English counties.

There remain about a score of birds which have bred once or twice or irregularly in the British Isles since 1900, but cannot yet be counted as regular breeding species. Five passerine birds fall within this category, the Brambling, Redwing, Moustached and Icterine Warblers and Tawny Pipit, as well as one near-passerine bird, the Bee-Eater. Both the Brambling and the Redwing are regular winter visitors to Britain which have several times been suspected of staying to breed. This was proved for the Brambling in Sutherland in 1920, and for the Redwing in the Moray area in 1932 and 1933 and on Fair Isle, between Orkney and Shetland, in 1935. One of the most astounding events in recent British ornithology was the breeding on a Cambridge sewage farm in 1946 of a pair of Moustached Warblers, a bird which normally inhabits the Mediterranean area and which had only once before occurred in the British Isles. It is much more likely that the Icterine Warbler and the Tawny Pipit have nested on other occasions and been overlooked; the known records are for Wiltshire in 1907 (warbler), and Sussex in 1905 and possibly also 1906 and 1945 (pipit). Then there is the extraordinary attempt of a pair of Bee-Eaters to nest near Edinburgh in 1920.

Several species of duck, notably the Wigeon, Tufted Duck and Goosander, colonised the British Isles as breeding species during the nineteenth century, and since 1900 there have been sporadic attempts by others. Scaup, for instance, bred several times in the Outer Hebrides between 1900 and 1913, and apparently in Lincolnshire in 1944, while Long-tailed Ducks nested in the Orkneys in 1911 and probably other years as well. Goldeneye rather surprisingly bred as far south as Cheshire in 1931–2; their nearest normal breeding grounds are in Iceland and north Norway.

Several waders have nested from time to time in England during the past fifty years without yet establishing or re-establishing themselves. They include the Black-tailed Godwit, which bred in Lincolnshire in 1942, elsewhere in England in 1937, and in Scotland in 1946; Temminck's Stint, which attempted to breed on the shores of a Highland loch in 1934 and 1936; the Ruff, which nested in Norfolk in 1907, 1922 and possibly other years, also at the mouth of the Tees from 1901 to 1904 and possibly in Lancashire in 1910; the Green Sandpiper which bred in Westmorland in 1917; the Black-winged Stilt, of which two pairs bred on a Nottingham sewage farm in 1945, for the first time on record in the British Isles (Fig. 4); and the Avocet, which in addition to breeding in Ireland in 1938 aroused the interest and delight of British ornithologists by returning to breed in two colonies in eastern England in 1948. Finally, a small colony of Black Terns nested on ground

flooded for military reasons on the coast of Sussex in 1941 and 1942.

All British bird-watchers are eager to learn what the coming season has in store in the way of new species, and especially whether the avocets have returned, but it is to be hoped that the birds' chances of breeding will not be wrecked by 'rubbernecks', who in their anxiety to see a new bird are liable to spoil its chances of breeding.

READING LIST

W. B. Alexander and D. Lack, "Changes in Status among British Breeding Birds", *British Birds*, **38**: 42–5, 62–9, 82–8. (1944).

British Birds, *passim*, 1907–48.

E. M. Nicholson, *Birds in England*, London, 1926.

H. F. Witherby and Others, *The Handbook of British Birds*, London, 1938–41.

Baxter, Evelyn V., "A Century's Changes in Scottish Ornithology", *Scottish Naturalist*, **60**: 11–19 (1948).

Insect Repellents

AMONG the problems which ought to have been intensively studied long ago, but about which practically nothing was done until the military needs of World War II made immediate and thorough investigation imperative, was that of finding effective insect repellents. During the war armed forces operating all over the world were brought into forcible contact with medical entomology, in particular with the danger from the malaria-carrying mosquito.

It soon became apparent that the standard Army 'anti-mosquito creams' were unsatisfactory, being insufficiently repellent and too unpleasant to use in tropical conditions. Investigations were undertaken both in the laboratory and in field conditions by most of the Allied governments, and a neglected subject which had been full of 'mumbo-jumbo' and conclusions drawn from insufficient evidence received a very great stimulus.

Among the disadvantages of the earlier creams based upon citronella oil was the fact that in warm conditions the citronella was dissipated within an hour or two, when the base material actually served to attract some species of mosquitoes. This necessitated frequent re-applications of this rather unpleasantly greasy material. It was known, however, that some service men used the product exclusively as a substitute for brilliantine! The task of the scientists was therefore to find a repellent that would be pleasant to use and have a long effective life.

Among the many products investigated were 'vanishing creams' based upon partially saponified stearin, and containing high concentrations of pyrethrin extracts. Against certain mosquito species found in the Near East, these creams were effective, but the high costs and limited supplies of pyrethrins at that time were a disadvantage, and manufacture was a skilled and expensive process.

The writer recalls a field test at which he assisted, which took place in a swamp 'at dead of night'. Those of us conducting the experiment moved around in head-veils —looking like strange ghosts as we were illuminated from time to time when torches were switched on—to count feeding mosquitoes on our prostrate 'victims'. The unfortunate subjects of this test were a number of the local inhabitants, persuaded to lie out upon the ground in 'random distribution'! For the purpose of this work, it was necessary to *wash* a number of control subjects before applying the various test repellents, it having been shown in Africa and elsewhere that the exhalations from human beings and from unwashed clothing can be definitely attractive to mosquitoes.

A great number of other substances have been tried, including some made up in gums to be painted on the skin, but since those earlier days most other repellents have been largely superseded by the esters of phthalic acid called dimethyl phthalate and dibutyl phthalate. The period of effectiveness of these is undoubtedly longer than that of most others, and the smell and texture are not particularly repulsive to man—this is an important point. No substance is ever likely to be 100% repellent to insects, since experiments show what reason expects, that there will always be the odd suicidal insect which will bite through any repellent, even though it dies for its rashness. All living things vary, and one widespread variation is apparently obstinacy. Scientific 'laws' are generalisations from facts observed, and in any event animals do not read the text-books which describe them. If one enunciated a law to cover this point, it would have to be called 'The Law of Maximum Cussedness'!

Dibutyl phthalate has proved of value as a mite-repellent, and has therefore been used in preventive measures against scrub typhus, while dimethyl phthalate is of value against troublesome midges (of the genera *Simulium* and *Culicoides*) and against horseflies (Tabanidae), as well as being a first-class mosquito-repellent. These two substances are probably better used alone rather than in creams. One of their disadvantages is the fact that they are good solvents of the new 'plastics' so that such articles as 'unbreakable' watch-glasses and fountain-pens may be spoiled if the repellent is allowed to touch them.

It is unfortunate that, so far, no really efficient repellent has been found against the common horseflies (*Musca*) of the various parts of the world where these insects cause great irritation by their habit of clustering on the face in large numbers. They are believed to be seeking moisture, and are annoyingly persistent. The notorious Egyptian flies are probably among the worst in this respect. Local remedies include the application of antimony compounds round the eyes, or even the use of crushed malachite (a copper-containing compound), but it is doubtful whether these are of much real value. The subject of deterrents which would prevent the sheep blowfly (*Lucilia*) from laying its eggs on sheep is a large one and needs to be discussed separately: here it can only be stated that work in Australia has shown that oil from the Huon Pine (*Dacrydium franklinii*) seems promising for this purpose.

Recent work on control of adult mosquitoes by spraying the interior of buildings with DDT preparations has shown that DDT may sometimes exercise a repellent effect, if the insect settles for a brief time and picks up a sub-lethal dose. From the point of view of achieving control, this is a disadvantage.

In conclusion, may I relate the story of the British soldier who, confronted by a tin of cream bearing the instructions "smear on repellent", enquired as to which part of his anatomy was his repellent. R. A. D.

among British
32–8. (1944).

Birds, London,

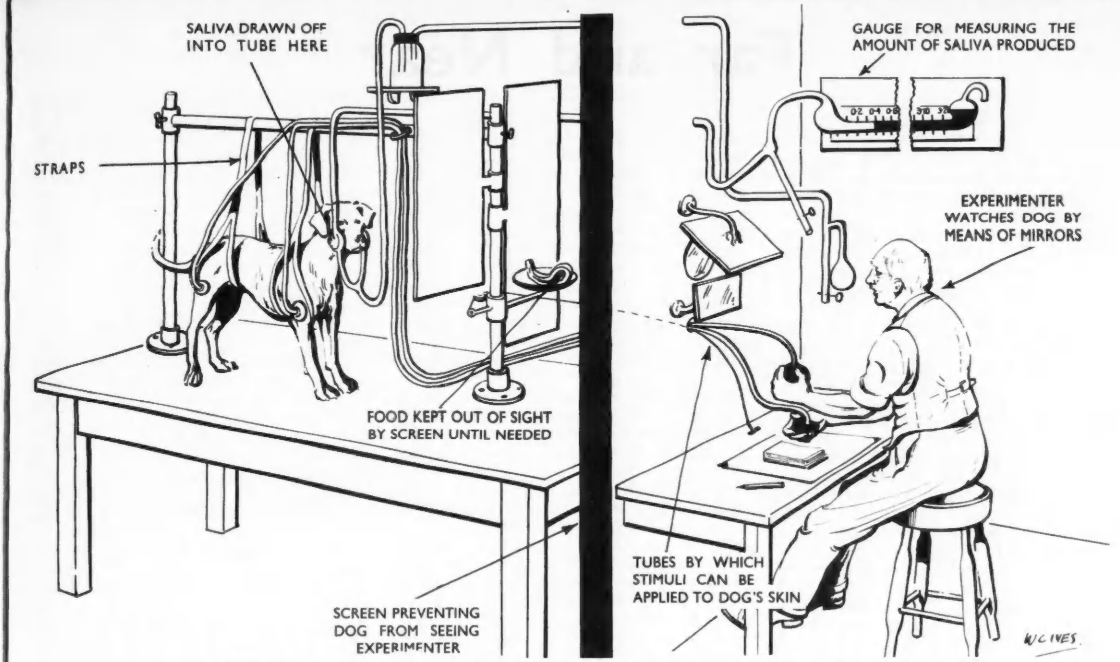
n Ornithology",

The period of than that of ot particularly int. No sub- insects, since at there will bite through ess. All living is apparently sations from not read the iated a law to 'The Law of

nite-repellent, asures against value against nd *Culicoides*) being a first- ces are prob- ms. One of good solvents 'unbreakable' poiled if the

ient repellent flies (*Musca*) insects cause n the face in ing moisture, ous Egyptian espect. Local y compounds malachite (a btful whether of deterrents *Lucilia*) from needs to be stated that ne Huon Pine is purpose. s by spraying ns has shown t effect, if the b-lethal dose. this is a dis-

f the British bearing the as to which
R. A. D.



This is the kind of arrangement used by Pavlov, the Russian scientist, who was first to study conditioned reflexes, in some of his experiments with dogs. The sketch shows how the saliva is collected and measured. The scientist remains out of sight throughout the experiment; sight—or sound—of the experimenter could arouse the animal's interest and upset the conditioning process. Pavlov found that a dog can be made to associate the sight or smell of food with its taste, saliva being secreted when it sees or smells a piece of meat for instance. This response is called a conditioned reflex.

JUNIOR SCIENCE

What is a Conditioned Reflex?

In June and July I wrote as if the nervous system were a static, unchanging thing—as if it were a sort of machine that works if we press the right buttons, but does nothing otherwise. When, for instance, you tap somebody below the knee-cap and get a knee-jerk (as I described in July) it is like pressing a button and getting an automatic response that never varies—unless the works are out of order.

But of course, as we all know, behaviour varies. For instance, we learn to do new things. Some learning is very simple. Take for example the production of saliva, or spittle, in the mouth. When food is put on the tongue saliva is produced. (Actually it is made by glands—the salivary glands in the cheek and below the tongue; each gland has a fine tube leading into the mouth. Its function is to help in digestion, and to lubricate the food as it goes down.) The production of saliva is another example of a simple reflex: sense organs on the tongue are stimulated; impulses travel along nerves to the brain, and out from the brain along other nerves to the salivary glands; and so the glands are made to secrete saliva. You will notice that this time the motor nerves—the ones carrying impulses *from* the brain—stimulate *glands* to act, instead of muscles.

The action of producing saliva can be induced, not only by tasting food on the tongue, but even by smelling or seeing it. The obvious example is seeing a lemon; I dare say that even my mentioning a lemon is making your mouth water. Certainly, if you show a lemon to a trombone player he is liable to blow bubbles instead of playing the tune. (But do not think I am suggesting *that* as an experiment.)

What has all this to do with learning? The point is, when you first begin to produce saliva, as an infant, you do so only when you taste food. But after a time the mere sight of food causes saliva to be produced, because in the past seeing food has always, or nearly always, been followed by tasting it. A process of this sort is called *conditioning*. When your mouth waters at the sight of a lemon, that is an example of a *conditioned reflex*. A simple reflex is one that happens without previous learning: you do not learn to do a knee-jerk, or to sneeze, or to contract the pupil of your eye in a bright light; these are examples of simple reflexes. But when you produce a reflex action in response to a *new* stimulus (such as the sight of a lemon instead of the taste) then that is a conditioned reflex.

Of course, all sorts of actions can be conditioned. There is a story of a man who kept hens. When hens see grain being thrown on the ground they run towards it. This man used to blow a motor horn before he put down his hens' food, and so they became conditioned to run towards the sound of a motor horn. Whenever a cautious motorist sounded his horn as he went by, the hens used to rush into the road; some would be killed. The owner would then claim heavy compensation from the motorist. He got much more money that way than by selling the hens or their eggs. (You need not believe this story, but you will see the point, I hope!)

Not only can you condition animals (or people) to *do* something; you can also condition them *not* to do something. You can even condition them to go into a state of general inactivity—in other words, to go to sleep. You will remember I wrote last month that one of the functions of the nervous system is to *inhibit* activity, as well as to stimulate it. In one series of experiments some dogs were given a drug that made them go to sleep. When this had happened to them several times they were given not the drug, but plain water, injected in the same way as the drug. They went to sleep as before. In fact some of them went to sleep as soon as the experimenter appeared with his syringe. Some people have difficulty in getting to sleep. One thing they may find useful is always to go to bed at exactly the same time, and to do the same things before doing so. They may then become *conditioned* to sleeping after doing these things.

Anthony Barnett.

Far and Near

30-Million-Volt Synchrotron

FOLLOWING the operation of their first synchrotron in 1946, the Electronics Group of the Ministry of Supply's Atomic Energy Research Establishment (working at TRE, Malvern) has now made a larger machine, producing 30 million volt X-rays. The machine was constructed in association with industrial firms, prominent among them being the English Electric and General Electric companies. The present machine accelerates electrons until they are travelling so rapidly that their mass increases to sixty times its normal value. The 30 million volts which such accelerated electrons can produce would give a spark some 50 yards long in normal air—yet nowhere in this apparatus is an accelerating voltage used greater than that of a normal wireless battery. This small voltage is, however, applied more than 2 million times in the thousand miles long path of the electrons through the machine.

The 30-million-volt synchrotron has been developed for two main purposes. First it is acting as a model to provide information for the design of the very high-energy machines now being constructed in Britain. Among these is the 300-million-volt, 150-ton, synchrotron being constructed by Metropolitan Vickers in association with the A.E.R.E. and Professor P. I. Dee of the University of Glasgow, where it will be used for fundamental research in nuclear physics. The second use of the synchrotron is a medical one. The X-rays which are produced by the 30-million-volt electrons are so penetrating that they should make it possible to treat malignant tumors deeply seated within the human body, and at present not easily accessible to external radiation.

Chemical Research Laboratory on Show

FOR the second time since the War, the Chemical Research Laboratory at Teddington recently held an open day. To visiting technical journalists, Dr. Linstead, C.B.E., F.R.S., the director, acknowledged the obligation of this Laboratory, supported as it is by public money, to disclose its work to the public, and this responsibility is discharged by exhibitions, general and special reports, and publications in the Press.

In the section studying metallic corrosion, the well-known protective films on stainless steels have been stripped, using an extremely delicate method, and examined by chemical analysis, electron diffraction and electron microscopy. Enrichment of the surface layers of the steel (and of the film) in chromium as compared with the bulk of the steels has been confirmed.

Prevention being better than cure, it was pleasing to see a valuable new process that gives temporary protection of metals. Metals dipped into a suspension containing 55% rubber latex and 5% sodium benzoate were found to be unattacked even under severely corrosive conditions. Protection is attributed to a film of basic ferric benzoate. The discovery is patented as applicable to a variety of benzoates incorporated in a number of film-forming materials—regenerated cellulose, polyvinyl acetate and so on—as intimate wraps. Sodium benzoate is a well-proved inhibitor of corrosion, and a 1½% solution in water will protect circulating water systems.

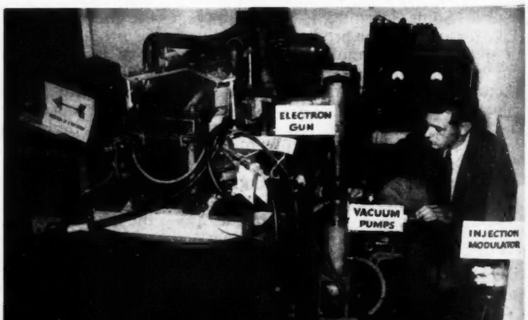
Silicones, hitherto produced only in America, may become a home product if developments in the Organic Group of CRL are successful. Using a 'direct' synthesis—methyl chloride is passed over silicon, with a copper catalyst—the intermediates have been successfully produced without employing the expensive Grignard synthesis. Methylchlorosilanes, which are water-repellent, will be of value for maintaining insulation in humid conditions. The heat-resisting properties of the silicones are already finding use in the manufacture of paints for metal smoke-stacks, special rubbers and oils for vacuum diffusion pumps. Difficulties of industrial development of these compounds are not entirely technical. The CRL Report *Chemistry Research 1938 to 1946* observes that "the formulation of industrially useful compounds remains shrouded by an extensive and all-embracing series of patent specifications".

The Chemical Research Laboratory is engaged on a programme of work for the Department of Atomic Energy. Analytical chemistry of uranium and thorium is being studied, and also physical methods of analysis based on measurement of radioactivity. Minerals, for example, are assayed by sealing for one month, to attain radioactive equilibrium and determine the amount of radon gas present; the gas thoron is removed and the radon is swept forward to an automatic counter, which gives the analyst his answer on a ticker-tape.

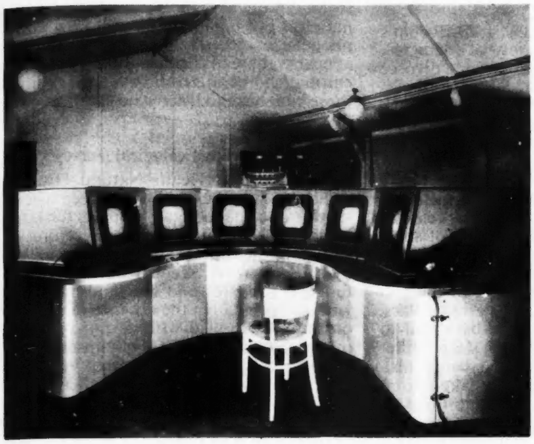
Obituaries

THE death occurred on July 26 of SIR CLIFFORD COPLAND PATERSON, F.R.S., founder of the Wembley Research Laboratories of the General Electric Company, which were established in 1919. He was born on October 17, 1879, and received his education at Mill Hill School and Faraday House. In 1901 he joined the staff of the National Physical Laboratory when it was still a fledgling institution, and he remained there until 1918, when he left to become research director of G.E.C. An authority on lighting, he served on several Government committees which reported on lighting in streets and factories and navigation lights. During the first World War he contributed to the design of the Paterson-Walsh electrical height finder, which gave an automatic record of the height of aircraft. He was particularly noted for his popular lectures, illustrated with an abundance of demonstrations, and almost the last of these, delivered at the electron jubilee celebrations last year, was published in DISCOVERY (December 1947).

DR. FRANZ WEIDENREICH, the famous German-born anthropologist, died in Manhattan in July. He held the view that man was descended from a giant ancestor rather than from a pigmy ape-man, and this ancestral form, called *Gigantopithecus*, he dated as 450-550,000 years old.



(*Left*).—30-million-volt synchrotron developed by the Electronics Group of the Atomic Energy Research Establishment, working at the Telecommunications Research Establishment.
(*Right*).—15-million-volt synchrotron.



(*Left*).—The six P.P.I. screens which give a complete picture of Liverpool Harbour and its approaches in fog. (*Right*).—Douglas Harbour, Isle of Man, can also be worked in all weathers, thanks to radar. This photo shows the 60-foot scanning tower (*left*).

Supervising Liverpool Docks by Radar

ON July 30 the First Sea Lord officially opened the Liverpool Harbour Supervision Radar Installation, which shows the whole of the Merseyside Docks and the approach channel on an overlapping series of P.P.I. screens. This, the first specially designed Port Radar System in the world, enables all ships approaching or leaving Liverpool Docks to be plotted and the exact situation in fog or bad weather to be seen at any moment and communicated to the Mersey Docks and Harbour Board, who can communicate with ships and pilots. The installation results from the co-operation of Sperry Gyroscope Co. Ltd. and A. C. Cossor Ltd., technical advice being given by Sir Robert Watson-Watt and Partners.

Anti-anaemia Factor contains Cobalt

THE anti-pernicious anaemia factor, isolated from liver and called vitamin B12 (see DISCOVERY, July 1948, pp. 203-204) contains cobalt. This unexpected news is given in a letter by Dr. E. Lester Smith, leader of the Glaxo team which isolated the factor, published in *Nature* on July 24. It seems likely that the substance contains one atom of cobalt, and that its molecular weight is about 1600. The discovery, which has been confirmed by the American team working on vitamin B12, is of peculiar interest as the presence of cobalt in an isolated compound of natural origin has not been previously reported.

Conserving Uranium

CONSERVATION of uranium supplies has become necessary as a result of the atomic energy projects now in hand, and the Chemical Council has been informed by the Board of Trade that no further quantities of uranium compounds can be supplied to dealers for many months to come. Uranium compounds available will therefore be limited to the small stocks now held by dealers and users. In order to conserve these materials it is recommended that uranium compounds should only be used for research purposes and for sodium estimations, but not in phosphate determinations.

London Club Facilities for Scientists

THE Society for Visiting Scientists is now able to extend its facilities and membership for scientists resident in the United Kingdom. Applications for membership from interested scientists will be welcomed, and applicants should apply to the Assistant Secretary, SVS, 5 Old Burlington Street, London, W.1, mentioning one or more members of the Society who would be willing to be their sponsors. The subscription for members resident in the United Kingdom is three guineas per annum, with an entrance fee of one guinea. Visiting scientists from overseas are charged an entrance fee of five shillings only, and pay an annual subscription only if they reside in the United Kingdom for more than six months. The Society now has over 1300 members, about 1170 of whom are overseas. In addition to the opportunity of meeting visiting scientists, and thus furthering international contact and friendship among scientists, the Society's premises offer useful club facilities.

A report of this month's meeting of the British Association at Brighton (8–15 Sept.) will be printed as a supplement to the next issue of DISCOVERY and issued free with each copy.

Scientific Literature and the Metric System

THE National Physical Laboratory has produced a fourpenny pamphlet which gives valuable guidance to authors and editors as to the most convenient way in which they can make their writings easily intelligible to readers unfamiliar with British units. Users of the scheme proposed in this document, which is entitled *The Inclusion of Equivalent Metric Values in Scientific Papers*, are invited by the director of the NPL, Sir Charles Darwin, to send him comments and suggestions based on their experience, in the light of which the scheme may be revised.

New Van de Graaffs for Britain

Two high-voltage X-ray generators are being sent to Britain under export licence from the V.S. Atomic Energy Commission. The licences are the first granted for export of such equipment. Both instruments are 2-million-volt Van de Graaff machines, which because of their small size can be orientated to give a directional beam of X-rays convenient for the treatment of cancer patients, radiography of metal parts in industry, and so on. Approximate dimensions are as follows: length, 5½ feet; diameter, 3 feet; length of belt, just over 2 feet. The engineer chiefly responsible for their design is John Trump, working in collaboration with Professor Van de Graaff of Boston 'Tech' (Massachusetts Institute of Technology). The National Physical Laboratory, Teddington, will get one instrument and the Sheffield National Centre for Radiotherapy, the other. The NPL plans to use the machine for X-ray standardisation of dosage and protective levels. The generator going to Sheffield will be used in research on radiotherapeutic techniques and cancer studies.

£1 Million Grant Towards Malay University

THE Secretary of State for the Colonies has approved the allocation of £1,000,000 from the Higher Education Allocation of the Colonial Development and Welfare Funds towards the cost of the new University of Malaya.

Olympic Games and Food

AT their last meeting the Nutrition Society discussed the nutrition of athletes. Sir Adolphe Abrahams cast doubt upon the necessity of the huge calorie intakes recorded for athletes at the Berlin Olympiad in 1936. The competitors at those Games were said to have consumed on an average 7300 calories daily, including 800 grams of meat, 150 grams of sugar, 150 grams of butter and 1–2½ litres of milk. Sir Adolphe pointed out that a calorie consumption at this level, corresponding to an energy output equivalent to running 100 miles at moderate speed, would only be required by men doing 5–6 hours violent exercise a day, and no athletes in training do this. A sprinter in fact makes two visits to the track a day and on each occasion he has a few 'bursts' from the start and a run through of 150 yards. Even in long and sustained effort such as the Oxford and Cambridge Boat Race, only about 500 calories were expended per man. Athletes who claimed to be vegetarians, invariably, said Sir Adolphe, consumed animal products such as milk, butter, cheese and eggs of which three were potent sources of animal protein. There was no particular value in giving sugar to athletes before events. In violent efforts, said Sir Adolphe, there was not time for extra sugar to be adequately mobilised. The exhaustion of the marathon runner did resemble hypoglycemia (abnormally low blood sugar), but while some marathon runners who collapsed had abnormally low blood sugars others did not.

Dr. Nevil Leyton, a believer in the value of extra sugar being taken two hours before a race gave some interesting comparative calories figures for athletic events. He stated that whereas the Oxford and Cambridge Boat Race required about 500 calories per man, a marathon runner may need about 2000 calories for his event and a long drawn-out tennis match some 1200 calories.

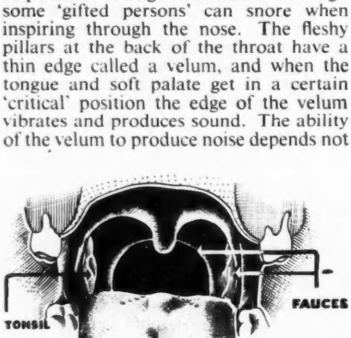
Dr. G. H. Bourne pointed out that vitamins of the B complex were associated with carbohydrate metabolism and that, therefore, it might be expected that they would be required in increased amounts in muscular exercise. If the normal requirement were greatly increased it might be difficult to obtain all that was needed from natural foods and the athlete's performance may, therefore, be limited by his vitamin intake, the latter being itself limited by the amount of food the athlete can consume. It is possible that the desire on the part of the athlete for foods such as meat, liver, eggs, etc., may be for the vitamins rather than the proteins which they contain.

Interesting papers were also given to the Meeting by Dr. Philip Eggleton and Dr. Dorothy Needham, F.R.S., who dealt respectively with the physiology and biochemistry of muscular action. Neither Dr. Eggleton nor Sir Adolphe Abrahams believed that the steadily improving athletic records indicated some athletic evolutionary progress. They thought that they were partly due to improved technique and partly to the fact that more and more people were becoming interested in athletics.

Snoring

SNORING, according to Dr. I. G. Robin's lecture to the Royal Society of Medicine, is considered justification for divorce in some parts of the U.S.A. It is certainly capable of ruining the happiest marriage, and, as Dr. Robin says, because it is regarded as something comic, the snorers themselves have difficulty in having their 'complaint' taken seriously and the sufferers from their nocturnal cacophonies have even less chance. Dr. Robin is precise in his definition of snoring—all noisy nocturnal respiration is not snoring—and he limits true snoring to the noise caused by the vibration of the soft palate and the posterior fleshy pillars, known as the fauces, at the back and to the sides of the throat, during sleep. Other parts of the mouth and throat may also flap about during sleep and make noises, but Dr. Robin will not admit these as snores.

True snoring usually takes place during inspiration through the mouth although some 'gifted persons' can snore when inspiring through the nose. The fleshy pillars at the back of the throat have a thin edge called a velum, and when the tongue and soft palate get in a certain 'critical' position the edge of the velum vibrates and produces sound. The ability of the velum to produce noise depends not



only on the position of tongue and soft palate but also upon its texture, and this is to some extent itself dependent upon the 'tone' of the muscles which support it.

Snoring, since it occurs most usually during mouth-breathing, is sometimes due to nasal obstruction, and suitable treatment of the obstruction usually clears up the trouble. This is the common cause and cure in young children, tonsils and adenoids being the usual sources of nasal obstruction. Changes in the throat due to disease may also pre-dispose to snoring, and sometimes relaxed muscles in the throat, either temporary or permanent, may be responsible. Elderly men and women who start snoring usually do so because of lack of muscle tone in the throat. Some healthy adults tend to snore whenever they turn on their backs at night. They can be discouraged from doing this, according to Dr. Robin, by having a cotton reel sewn into the back of their pyjamas. Sometimes failure to keep the mouth closed during sleep irrespective of the position of the body is the cause of the trouble. A special splint can be used to keep the mouth closed in these cases or a more simple remedy such as a strip of adhesive plaster across the corners of the mouth may be used. In some cases regaining of muscular tone of the throat muscles by breathing, swallowing and phonetic exercises give good results. It appears there is some hope for the chronic snorer after all, or perhaps it is those who have to listen who should really take heart.

Hampstead Heath Ecological Survey

THE Hampstead Heath Natural History Society is carrying out a general ecological survey, and the secretary appeals for help in connexion with several insect orders including the diptera, the orthoptera, the hymenoptera; it seems that the local fungi, bryophytes and arachnida are still without friends. In the absence of experts on the spot to deal with certain sections of the survey work, the organisers have adopted a system of 'external referees' which may commend itself to other societies. Many well-known biologists, living many miles from the Heath, are guiding the work of local amateurs, but more referees are still wanted. The local organiser is John Hillaby, 1 Tanza Road, London, N.W.3.

Directory of Natural History Societies

A DIRECTORY of natural history societies has just been published by the Amateur Entomologists' Society, 1 West Ham Lane, London, E.15. This comprehensive compilation, which gives details about school natural history societies as well as local societies and such organisations as the S.E. Union of Scientific Societies, runs to 155 pages, is well indexed and costs 7*s.* 6*d.*, post free. The work of compilation was started at the beginning of 1944 by W. G. Rawlings, who, however, had to relinquish the task owing to ill health, and it was completed by H. K. Airy Shaw. Beowulf A. Cooper acted as general editor of the directory, which carries an introduction by him urging the formation of a National Union of Naturalists and a foreword by Julian Huxley and R. S. R. Fitter on the role of local natural history societies.

Century of Safety Matches

THIS year brings celebration of two milestones in the progress of the match industry: namely, the introduction of red amorphous phosphorus 100 years ago, and of phosphorus sesquisulphide 50 years later. The paramount importance of these two discoveries is appreciated by contrasting today's simple, casual match-striking with methods of creating a vital spark in the past. From the friction between two bits of wood, from flint and steel and tinderbox, a first step was Boyle's sulphur-tipped splints drawn at peril through folded coarse paper coated with phosphorus, that is, dangerous white phosphorus. De Latour, inventor of the siren, tried sulphur splints and a 'phosphorus bottle', which was as risky an object to carry in the waistcoat pocket as the bottle of vitriol that used to be used with splints tipped with chlorate of potash, sugar and gum. All such flame-conjuring proved troublesome, with the spontaneous combustion occurring at the wrong moment.

Between those early efforts and the

modern match of phosphorus sulphide, potassium chlorate, silica, ground glass, zinc oxide and gum, all compounded with high precision, one must pay tribute to the true pioneers. First John Walker in 1827, that apothecary who sold percussion powders as explosive 'caps' have been sold recently, and the first to sell friction matches—though still requiring folded sandpaper and still giving too many sparks and fumes. Then, after the Viennese Professor Schrötter discovered red amorphous phosphorus, non-poisonous and not spontaneously inflammable, there began years of endeavour to replace the white phosphorus which caused 'phossy jaw' among match-workers. In 1848 red phosphorus entered into Swedish matches. A year later Arthur Albright, hearing Schrötter lecture in Birmingham, began his great crusade to banish white phosphorus, and to set up at Oldbury the most noted phosphorus factory in Europe. The Lundstrom brothers took back to Sweden some red phosphorus from the Exhibition of 1851, tried it with success on the *outside* of boxes, and the safety-match was born and bought from the Lundstroms by May of Bryant and May.

Today no further match-making possibilities are contemplated beyond novelties. There are drunkards' matches, self-extinguishing half-way down, and water-proof matches for the speleologist and explorer. And there is the restrikable match, not yet successful. Readers may care to try out an igniting composition repeated at intervals down a strip of partially combustible material; or follow in full English Patent 329,796 of the German I.G. concern. An organic mass including nitrated cellulose, and a friction igniter of phosphorus or its sulphide, or antimony sulphide, etc., both used so that when the rate of combustion is reduced rapidly, re-ignition with fresh igniter is accomplished. The whole is moulded into rods and mounted like a propelling pencil.

The Atom Train

THE Atom Train exhibition, which ended its tour on May 28 was seen by 146,000 people, including about 12,000 school children who came in organised parties. The Atomic Scientists' Association has agreed to lend the whole exhibition to Unesco, which will put it on show during its annual conference at Beirut in October. Over 50,000 copies of the exhibition guide were disposed of, so this booklet, to quote the words of Dr. J. Rotblat, who deserves most credit for the organising of the Exhibition, has become one of the most popular and widespread publications on atomic energy.

New SCI President

NEW president of the Society of Chemical Industry is SIR DAVID RIVETT, 63-year-old Tasmanian, who is head of Australia's Council of Scientific and Industrial Research.

The Bookshelf

The Size of the Universe. By F. J. Hargreaves. (Penguin Books, Harmondsworth, 1948; pp. 175, 18 plates, 32 text figures, 1*s*. 6*d*.)

THE critic of a work of popular science is entitled to demand something more than even a publisher is likely to ask. The work should not only achieve the negative object of not being wrong: it should contribute positively to the public appreciation of the science, including its latest developments. It should be written in such a way that it is clear to the fellow professional that a careful consideration has been given to all the most recent researches, even though there may be no explicit mention of these in the text. Lastly there should be some novelty of presentation to provide a raison d'être for the work and to mark it off from all the other similar works which have been produced in the past.

Except for some slips of the pen, such as the attribution of the solar spectrum to the chromosphere, Mr. Hargreaves easily attains the negative object, and his book is clearly written and readily comprehensible. Judged by the other standards it does not do so well. Except for references to the solar parallax, and a fleeting mention of cosmic noise, there is little in the book which could not have been written twenty years ago. Planetary systems of other stars are discussed, but there is no reference to 61 Cygni. A reference at one point seems only capable of meaning support for the old idea of the 'local cluster' of stars near the sun, thus disregarding not only dynamical considerations but also the work of Oort. The orientation of the axes of nebulae is said to be random, in spite of contentions to the contrary. The final chapter on relativity is, in the reviewer's opinion, a mistake in tactics, since it does little to clarify the reader's ideas. The possibility of seeing the galaxy by light which has circumnavigated the universe has been shown to be invalid, even if the whole system of ideas should not be replaced by those of Milne.

Lastly, it seems unfortunate that so much support should have been given to the mistaken idea that all big telescopes are built and used in the U.S.A.

In spite of all this, the book is worth buying and reading. As an introduction to the subject it achieves its purpose so well that it is all the more unfortunate that the opportunity of writing a really brilliant book has been so narrowly missed. DAVID S. EVANS.

Feeding the Human Family. By F. Le Gros Clark. (Sigma Books, London, 1948, pp. 125, 7*s*. 6*d*.)

THREE-FIFTHS of the world's population is engaged in agriculture. Of these, nine out of ten are engaged in the production of food. If to all these we add the people concerned with transporting and selling food we find that 70 per cent of the people in the world are spending their lives in feeding themselves and the other 30 per cent. These significant facts have been given us by Sir John Orr and they represent the background against which Mr. Le Gros Clark's book should be read.

The author of *Feeding the Human Family* is himself well known as an earnest student of national and international food problems and he has delved deeply into, and chosen well of his store of knowledge in compending his book—one's only regret is that it was not many times its size so that we could have had more. It is meant, however, like other Sigma books to be an introduction to the subject and as such it fulfils its role admirably. Starting with a brief physiological introduction it goes on to deal with food consumption and famine in different parts of the world, discusses dietary habits and cereal intake and production, sugar and dairy products, meat and fat. His chapters on "One world, one farm" and "The fear of abundance" might well be read with profit by the politically inclined since they contain the germ, the very nucleus, of man's only hope of salvation. The whole book can be recommended to those who wish to obtain in a small compass some perspective of world food problems.

There is only one fault, but it is a serious one, particularly in a book of this character—there is no index. G. H. BOURNE.

Genetics. By H. Kalmus. (Penguin Books, Harmondsworth, 1948; pp. 171, 1*s*. 6*d*.)

DR. KALMUS reveals the magnitude of the task he has set himself in attempting to compress genetics into 171 pages when he says in the Foreword that while genetics is the youngest biological science it is responsible for more original papers (and hence, we presume, for more original research) each year than any other biological study except physiology. Much detail has obviously had to be omitted, and indeed should properly be omitted from such a semi-popular account. Nevertheless, the subject is approached in no narrow way; not merely are the principles and methods of formal genetics set before the reader, but he is also introduced to the cytological study of chromosome behaviour, to the biochemical study of gene action, and to the application of genetic principles in evolutionary theory, in the breeding of economic plants and animals, and in human affairs. The book concludes with a chapter exposing some common genetical and statistical fallacies.

It seems almost ungracious to criticise such a valiant attempt to push genetics into one small volume, for in such a case the critic's task is always much easier than the author's. And indeed Dr. Kalmus has achieved a notable measure of success. A

few comments may not, however, be out of place.

One wonders, for example, whether the somewhat elaborate introduction to variation, bringing in as it does matters astronomical, crystallographical and chemical, is really worth the space it takes in so condensed an account. One wonders, too, whether mention of the lack of recombination in the *Drosophila* male will enlighten rather than bewilder the reader. The fruit fly is anomalous in this respect, and while *Drosophila* must loom large in any account of genetics, it should do so surely only so far as it illustrates rules rather than confounds them. There are a few misprints, such as the reference on p. 104 to Fig. 18 where Fig. 19 must be intended; and there are occasional misrepresentations of fact, such as that auto-polyploidy is commoner than allo-polyploidy in cultivated plants, and that doubling of the flowers in *Primula sinensis* is due to the anthers being turned into extra petals. One feels that the author is more certain of his ground when dealing with animals than with plants.

The treatment is generally adequate within the limits set by considerations of space, but the policy, which borders on one of masterly inactivity, advocated in the chapter on eugenics, may seem to some readers over-pessimistic as anything other than a temporary expediency at best. The style is simple and clear throughout the book, though a somewhat forced jocularity creeps in at times, as when we are told that "of course, chromosomes are not really wool or wire——". But perhaps the most serious criticism is that although great pains are taken to explain, and to collect into a glossary, the technical terms of genetics, terms just as technical are taken from other branches of biology and dropped on to the reader without any merciful warning. 'Pelagic larvae', 'macro- and micro-nuclei of Infusoria', 'plasmodia of some Myxomycetes' may hold no terrors for the general biologist, but to the majority even of scientists they are surely no less intimidating than 'crossing-over', 'inversion' or 'vegetative reproduction'.

It would be idle to deny these blemishes; but the faultless account of genetics has yet to be written. Dr. Kalmus has given the student of biology a useful introduction to a great and growing branch of his subject. From it also, the non-biological scientist can learn how the biologist is developing an argument as rigorous and a theory as intricate as his own; though the layman may still find the technicalities troublesome. And all Dr. Kalmus's readers, non-biologist as well as biologist, the layman too if he is sufficiently pertinacious, will come to see that genetics is no idle intellectual pursuit, but a study which affects all our affairs and can even show us something of our own qualities and weaknesses, capacities and limitations.

K. MATHER.

Cosmic Rays and Nuclear Physics. By L. Janossy. (Pilot Press, London, 1948; pp. 177, 131 illustrations, 9*s.* 6*d.*)

THIS book gives a comprehensive but concise account of cosmic rays, and so far as present-day delays in publication permit, it is up to date. In many respects the book is excellent, and the chapters dealing with mesons are particularly welcome. At last we have in simple and concrete terms an explanation of how the meson is believed to hold the nucleons in an atomic nucleus together. The relationship of the meson field of the nucleus, the meson of cosmic rays, and the emission of beta particles by radioactive substances is made as clear as the limits of our present knowledge permits.

The book is most suitable for a student who has, say, just embarked on a course for a pass degree in physics or any reader who has an equivalent knowledge of physics and mathematics.

The Corridor of Life. By W. E. Swinton. (Cape, London, 1948; pp. 223, 85 illustrations, 15*s.*)

DR. SWINTON is both well qualified as writer and palaeontologist to present, in popular form yet in true perspective, the long sweep of zoological evolution, and he has been more than competently assisted by the attractive illustrations supplied by Miss Erna Pinner. There is probably no other book, and certainly no other recent book, which can be so confidently recommended as an outline guide to the subject. He begins with the cooling of the earth and the formation of oceans, as the physical setting in which life may be supposed to have originated, and discusses transitions at all important stages as well as achievements. Examples are the developments of shells or tests, which he thinks more likely to have been a chemical accident than due to any reaction to defence needs, and 'the great transition' to vertebrate structure. As to achievement, the reptiles when reached receive an allocation of space which is as great as that given to all earlier forms of life combined, and appreciably greater than that given to their successors. But, as Dr. Swinton points out, "no other group has so far equalled their dominance in time or diversity", and on that ground alone the proportion of space devoted to them can be defended. Finally, after reaching the sabre-toothed tiger, he leaves the historical sequence for a broader discussion of evolution and extinction as a whole. He emphasises particularly the frequent persistence of useless specialisation, and the fact that "all the great evolutionary steps came from simple, unobtrusive animals or groups that, once they had given birth, faded away".

The U.F.A.W. Handbook on the Care and Management of Laboratory Animals. Edited by A. N. Worden. (Ballière, Tindall & Cox, London, 1947; pp. 368, with 70 illustrations, 31*s.* 6*d.*)

THE U.F.A.W. (Universities Federation for Animal Welfare) has done a considerable service both to scientists and their experimental animals by the production of the present handbook. Animals that are contented and healthy are essential for proper experimentation and although all scientists have the maintenance of such animals as their object, few have sufficiently comprehensive knowledge or training to permit them to cope with all aspects of animal care.

The U.F.A.W. handbook first gives the legal requirement for keeping animals, then details the ideal animal laboratory, and then in a series of chapters it describes the special requirements for the different types of laboratory animal from the point of view of accommodation, nutrition, breeding, handling, anaesthesia, and disease and its control. The animals dealt with include the rabbit, guinea pig, various types of rats and mice, vole, hamster, ferret, hedgehog, pigeon, canary, certain amphibia and fish. It also provides names of persons from whom information concerning the care of animals not mentioned in the above list can be obtained.

This book must find a place on the shelves of everyone in Great Britain whose work involves the use of laboratory animals.

GEOFFREY H. BOURNE.

The Use of Auxins in the Rooting of Woody Cuttings. By Kenneth V. Thimann and Jane Behnke. (Maria Moors Cabot Foundation, Harvard Forest, Petersham, Massachusetts, U.S.A., 1947; pp. 272, 5*s.*; 1 dollar.)

SINCE the discovery of the root-forming activity of the plant-growth hormones nearly twenty years ago, a vast amount of literature has accumulated on the practical aspect of the subject. This literature is scattered throughout the scientific journals of the world, and the authors of this book have succeeded in bringing together the vast majority of the available data and tabulating it in a concise and easily available form. Even with the field restricted to the rooting of woody plants, a total of 291 original publications have been abstracted. Except for a brief preamble, in which the mode of presentation of the data is discussed, the whole book is in table form. Species are arranged in strict alphabetical order, and simple details of concentration and type of hormone, method and duration of treatment, etc., are recorded, together with the treatment given to control cuttings. Numerical details of rooting response are also recorded together with brief notes on points of particular interest regarding results and treatments. A complete bibliography is given for all the results quoted. A small table of four pages at the end of the book treats similarly with more recent work on the influence of wounding on response. The total number of species and varieties covered is of the order of 1500.

It should be noted that this book (which is the first publication of the Maria Moors Cabot Foundation, established a decade ago to "promote education in the art of increasing the capacity of the earth to sustain human life") is not a book of practical rules for horticulturalists but is merely a compilation of the basic facts in the research literature arranged in a simple and easily available form. It is obvious that, with the extreme effectiveness of these hormones (many are effective at concentrations of 10 parts per million) and with the wide variation in sensitivity between species and even varieties of plants, no simple book of general practical instruction could be made fool-proof. With this simple tabulation of the data the practical man is left to work out his own methods from the knowledge available.

L. J. AUDUS.

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. Editorial Offices: 244 High Holborn, W.C.1.

ing animals
l laboratory,
apters it de-
nents for the
animal from
ommodation,
, anaesthesia,
The animals
, guinea pig,
mice, vole,
geon, canary,
also provides
information
als not men-
be obtained.
place on the
Britain whose
f laboratory
. BOURNE.

ing of Woody
Thimann and
Hoors Cabot
orest, Peter-
.S.A., 1947;

root-forming
h hormones
st amount of
the practical
literature is
ientific jour-
uthors of this
ging together
able data and
easily avail-
eld restricted
ts, a total of
ve been ab-
preamble, in
ation of the
e book is in
nged in strict
ble details of
f hormone,
atment, etc.,
he treatment
Numerical
are also re-
tes on points
g results and
bliography is
ted. A small
l of the book
cent work on
on response.
and varieties
00.
t this book
of the Maria
established a
cation in the
of the earth
ot a book of
ralists but is
basic facts in
anged in a
form. It is
me effective-
are effective
per million)
in sensitivity
varieties of
eneral practi-
e fool-proof.
f the data the
out his own
available.
J. AUDUS.